

# COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

*December, 1944*



*Photo by Paul W. Hall*

Changing gantry cranes for lowering a boiler into the hull of a tanker

**A. S. M. E. ANNUAL MEETING ►**

**Feedwater Treatment for High-Pressure  
Boilers at Dow Chemical Company ►**

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**C-E Marine Boilers  
help to give  
S.S. Bluefield Victory  
a "Clean Sweep"**



The Bluefield Victory — built at the Terminal Island yard of the California Shipbuilding Corporation

**S**PEED, economy, maneuverability—that's what it takes, among other things, to give a Victory Ship the okay of the U. S. Maritime Commission. And speed, economy and maneuverability to spare were demonstrated by the S.S. Bluefield Victory chosen by the Commission for Victory Ship Standardization Trials.

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For speed, operating economy, and maneuverability, any ship depends, in very large meas-

ure, on her boilers. The Bluefield Victory is powered with C-E Marine Boilers. Her trials are further proof that C-E Boilers, expertly designed and ruggedly built to give economical, dependable performance, do just that. For nothing escapes the rigid tests and scrutiny of the Maritime Commission's experts. To "take it" a ship has to have what it takes — from boilers to bilge pumps.

The Bluefield Victory is but one of many of the Victory class ships powered with boilers designed and built by Combustion Engineering. In fact, a substantial percentage of all the ships comprising the war-time program of the U. S. Maritime Commission — Liberties, Victories, C-ships, tankers and troopships — are equipped with C-E Marine Boilers.

A-8321

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C-E PRODUCTS INCLUDE ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; ALSO MANY TYPES OF PRESSURE VESSELS

# COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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FOR DECEMBER 1944

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**1908**

Introduction of thermal expansion type regulator invented by James W. Copes. The first real step toward effective feed water control.

**1913**

Copes Engineers announce new and revolutionary method of feed water control—"continuous feed varying with load, and level varying inversely with load."

**1916**

Initial research on flow through control valves, leading to design for individual boiler conditions. First 6-inch regulator ever made installed at Delray Station, Detroit Edison Company.

**1917**

Research into the influence of excess pressure variations on feed regulation, resulting in development of first differential pressure devices.

**1918**

Development of rotary stem control valves to reduce stem friction to low and constant amount, as against high variable friction of sliding stem.

**1919**

Manufacture of Copes Regulators begun in foreign countries. Within a few years Copes became the accepted standard in Europe, Asia, South Africa.

**1920**

Copes Regulators installed on 1100 psi. European-built boilers when 450 psi. was highest pressure in the United States.

**1921**

Originated tight seating valve fittings having equal upper and lower seat areas. Patent granted.



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**1924**

Copes Regulators designed with expansion tubes in TENSION set new record in simplicity and reliability. Patent granted.

**1926**

First successful multiple element feed water control—Copes—installed at Ford Motor Company.

**1927**

Copes installed on first 1400 psi. boilers in the United States—Boston Edison Company.

**1928**

Basic patents secured on combination of feed water regulator and differential pressure valve.

**1930**

First 8-inch feed water regulator—a Copes—installed at New York Steam Company.

**1932**

After careful tests and investigations, all radio controlled ships of U. S. Navy equipped with Copes Regulators.

**1934**

Six years' research completed with development of first valves really balanced under operating conditions. Patents granted on 2 types of 3-element regulators.

**1937**

Patents granted on remote control of feed water regulator and other control valves.

**1938**

Produced the Copes Flowmatic—a 2-element regulator—recognized as one of the greatest advancements in the art of feed water control for modern boilers.

**1941**

Introduced a Copes Marine Regulator not influenced by roll or pitch of the vessel. Now installed on hundreds of ships.

**1942**

Copes Flowmatics installed on largest forced circulation boiler in the world—850,000 lbs. per hour at 1825 psi.—Montaup Electric Company.

**194X**

Peacetime application of developments and improvements fostered by intensive war production activities.

# EDITORIAL

## A.S.M.E. Papers

The record attendance and scope of the recent A.S.-M.E. Annual Meeting attests both to the rôle of mechanical engineers in the war effort and to the many problems and developments arising directly or indirectly from it. However, the magnitude of such work was responsible for one unfortunate aspect of the program in that it was necessary to hold many simultaneous sessions throughout the week and, in some sessions, to include more papers than permitted adequate discussion in the allotted time.

Furthermore, at a time when everyone is unusually busy, it was difficult to secure many of the more important manuscripts sufficiently in advance of the meeting to permit preprinting and distribution at the sessions. This tended to curtail discussion.

Bearing in mind that today the interests of most mechanical engineers are no longer confined to narrow specialization but extend to many branches of the field, it would have been desirable had opportunity been afforded to attend sessions on allied subjects without conflicting with those dealing with an individual's primary interest. Many comments to this effect were heard.

Just how this could have been brought about is difficult to answer. Some professional divisions had from five to seven sessions, sufficient perhaps to have warranted separate regional meetings; or it might prove profitable to re-present certain of the more important papers at local meetings so that the information contained could be more widely disseminated and discussed by those most concerned. Frequently, the greatest value of a paper lies in the discussion it evokes.

Most of the papers and talks at the meeting were excellent and the program committee deserves unstinted credit for its efforts, despite the handicaps of a crowded schedule. On the whole, it was a good meeting.

## Trends in Energy Demand

Although total production of electricity for public use for the twelve-month period ending October 31, 1944, was substantially above that for a like period the previous year, reports issued by the Federal Power Commission for the last few weeks indicate that a slight decrease in average daily consumption has set in, if seasonal demand be discounted. To some extent this may be a reflection of the decrease in munitions production of which one reads so much in the daily press or hears over the radio. Success in the present efforts to stem the shift of manpower from war production to industrial jobs may serve to reverse this trend, although the present large stocks of certain basic materials which re-

quired vast quantities of electric energy in their production and the consequent shutting down of numerous plants in which they were produced is undoubtedly a factor.

In the light of developments in the European war theatre, the premature forecasts on power demands for the first half of 1945 must be revised and there is very little agreement as to the probable situation when Germany is defeated. Some predict a sudden sharp reduction in the use of industrial power, whereas others believe that the drop will be gradual, followed by a rapid increase in demand. The present indications of protracted war in the Pacific would appear to substantiate the latter view, although conditions are certain to be different in different localities.

The time required to build and equip power plants makes long-range planning necessary. In normal times this was not difficult, but at present the factors are so diverse and unpredictable that economic studies in this field no longer carry the element of assurance that was formerly possible. However, it is gratifying to read that certain of the electric utilities are showing the courage to announce very substantial expenditures for expansion and rehabilitation in the post-war period, and more are likely to follow suit.

## War Bonds

As this issue goes to press the Sixth War Loan is in its final stage. Indications are that quotas will be exceeded by dint of hard work on the part of those promoting it; but each successive drive, and there will probably be several more, requires extra effort. This is largely because backlogs of accumulated funds have shrunk and renegotiations have cut down anticipated profits—a fact that is being reflected in many company purchases.

The public is familiar with the efforts being put into local drives for the purchase of bonds by individuals, but it is doubtful that many are aware of the contributions being made by large companies through the time of their executives and other key men in putting over the bond sales, in addition to their very substantial purchases.

It is imperative that the costs of the war be met, and if a sufficient proportion is not raised by the sale of bonds, the only recourse is increased taxation. This is well understood, but it also emphasizes the necessity for rigid economy in governmental activities not associated with prosecution of the war or with the care of returning veterans. In other words, it demands critical examination of some of the post-war proposals now pending in order that the tax structure may not become unduly overburdened. Necessity rather than idealism must be the guide if we are to avoid future financial difficulties.

# A.S.M.E. ANNUAL MEETING

THE 1944 Annual Meeting of The American Society of Mechanical Engineers, held at the Pennsylvania Hotel, New York, November 27 through December 1, established a record for attendance with a total registration of approximately 3800. Moreover, the program of 62 sessions and nearly 200 papers, in addition to prepared discussions, luncheon talks and motion-picture presentations, exceeded that of any previous Annual Meeting. An idea of the scope may be gained from the fact that there were eight sessions on management and production, seven on heat transfer, six on applied mechanics, five on power, five on aviation, three on fuels, three on oil and gas power and others on boiler feedwater studies, furnace performance factors, dust and cinder recovery, education and training, hydraulics, process industries, materials handling, graphitization of steel piping, rubber and plastics, metals and metal cutting, railroads and post-war problems. Space here permits a review of only some of those papers which were of particular interest to power engineers.

## Future Trends in Fuels

A broad discussion of what is ahead in the availability and use of all kinds of fuels was handled by a panel made up of representatives of each major branch. *Bituminous coal* was represented by **Dr. H. J. Rose**, Director of Research of Bituminous Coal Research, Inc.; *Anthracite*, by **R. C. Johnson** of Anthracite Industries, Inc.; *Petroleum*, by **B. T. Brooks**, consulting chemical engineer; *Natural Gas*, by **W. C. Beckjord**, President of Columbia Engineering Co.; *Synthetic Liquid Fuels and Coke*, by **Dr. W. C. Schroeder**, Acting Chief, Office of Synthetic Fuels, U. S. Bureau of Mines; and *Manufactured Gas*, by **L. J. Willien** of the Institute of Gas Technology. **R. A. Sherman**, Supervisor of the Fuels Division, Battelle Memorial Institute, acted as chairman of the panel.

**Dr. Rose** emphasized that coal is the world's principal source of energy for heat and power, as well as for the making of iron and steel. It constitutes over 98 per cent of the total energy content of mineral fuel reserves in the United States in contrast to 1.3 per cent for the proved reserves of petroleum and natural gas. Furthermore, this country contains approximately half the world's known coal supply—enough to last us for 3000 years at the present rate of depletion, or when coal takes over the fuel demands now supplied by petroleum and natural gas, it will last for about 1750 years at the present rate of mineral-fuel consumption.

Now, however, coal producers, equipment manufacturers and industrial users, as well as state and federal bodies, are all devoting increased attention to coal research. The same applies to all coal-producing countries. Every phase of coal is being studied intensively, such as improved mining and preparation methods to ensure high quality at reasonable cost and improved equipment for burning the coal in power plants and in the home.

Since the last war there has been a 35 per cent increase in productivity per man-day, due to mechanization in coal mining. Over 80 per cent of the coal is now mined mechanically and about half the output is loaded mechanically. The present average earnings of miners in this country is \$220 per month. Transportation costs about equal mining costs. Mass production and the fact that potential capacity greatly exceeds demand should exert a stabilizing effect on bituminous coal prices.

Despite the increase in mechanization, costs in mining anthracite are going up and **Mr. Johnson** predicted that the future trend would be toward higher prices for this fuel.

According to **Mr. Brooks**, our known domestic petroleum reserves are believed to be about 20 billion barrels. Although during the past 20 years estimates of reserves have been frequently revised upward, due to new discoveries and extensions of existing fields, many of these fields have passed their productive peaks and newly discovered oil has reached an all-time low, despite greatly increased exploratory drilling. Present rates of production, as made necessary by war demands, are in excess of the economic optimum of most American fields and it was his opinion that we can no longer hope to meet our future normal domestic demands without some oil importation.

The cost of exploration and drilling in the United States has risen sharply in the last five years due to disappointment in new discoveries; and higher prices for crude oil and all petroleum products may be anticipated. The only factor that may curb an increasing price trend would be imported oil, but this curb may not result as foreign producers are likely to follow domestic price scales without depressing them.

With reference to utilization, **Mr. Brooks** stated that heavy fuel oils will continue as indispensable for naval vessels and most merchant ships. Other uses where oil competes with coal are probably due for drastic revisions, although not suddenly. The use of diesel oil merits much further extension. The burning of distillate fuels for heating he regarded as a gross misuse of a valuable and limited national resource, and rising prices of petroleum should favor gas heating.

**Mr. Beckjord** predicted that the cost of natural gas would advance because it will have to be produced from deeper wells and will need to be handled in many cases through long-distance pipe lines. Considerable natural gas is now being wasted in bringing oil to the surface, because in many localities it is not practical to construct pipe lines to carry this gas to the markets.

In the field of manufactured gas **Mr. Williams** stated that manufacturers are now going after space heating as an attractive market. They hope thus to increase the annual load factor and get greater production out of existing equipment, thereby offsetting increased production costs. In this connection, it should be possible to build up the summer load by the manufacture of blue gas or other bottled gases. Promising future developments are the enrichment of the gas with oxygen

instead of oil if the oxygen can be produced cheaply enough, and gasification of coal under pressure, as is now being done in Germany. Many low-temperature carbonization studies are now being made.

Dr. Schroeder referred to the development work on synthetic fuels recently initiated by the Government and being undertaken under the direction of the U. S. Bureau of Mines. He believed that if we can develop a program of synthetic oil production from coal or shale, that it would tend to place a ceiling price on imported oil. Inasmuch as the younger coals, as found in the West, hydrogenate more readily, it is logical to locate such plants in that section of the country. However, they generally give a lower yield per ton than the older coals. For hydrogenation it is desirable that the ash be relatively low,  $2\frac{1}{2}$  to 3 per cent, and that the sulphur be low, otherwise the product will have to bear the cost of sulphur removal. A ton of shale will yield from 15 to 20 per cent oil. Present costs of gasoline produced from coal by hydrogenation range from 14 to 22 cents per gallon, but it is anticipated that experience and development will reduce these figures, just as it has been possible in the last 25 years to reduce the average coal per kilowatt-hour in the electric utility plants from 3 to 1 lb.

#### Discussion

Many of the questions and much of the discussion concerned petroleum and synthetic oil. It was pointed out that new oil fields discovered in the past few years average only about one-tenth the capacity of those discovered ten or more years ago. Mexican reserves are not large; the same applies to those of Canada; and South America can supply only a limited amount; but the world's greatest present potential supply is in Arabia where prospecting has heretofore been restricted. Unfortunately, development and future availability of oil from the Arabian fields is tied up with international politics.

Reference was made to the much-publicized underground gasification of coal in Russia but it appears that authentic information is lacking; at least, attempts to gain first-hand information on this work have not succeeded. From such meager information as is available it would appear that the process involves pumping oxygen into the coal seams.

#### Fuels in Marine Use

Presented at another session of the Fuels Division was a paper on "Handling and Burning Fuels on Board American Ships," by David Schoenfeld of Combustion Engineering Co. and G. P. Haynes of Todd Combustion Equipment, Inc. The authors emphasized that future trends in the selection of fuels for merchant marine use will continue to be governed by the economic factors which now favor oil over coal. However, under the stimulus of present emergency conditions, many previous conceptions and customs concerning marine fuels are undergoing pronounced changes. This tendency, they believe, will continue in post-war years.

"It would not be surprising to find conventional hull arrangements modified to accommodate coal instead of oil," they stated. "With any shortage of fuel oil and accompanying increase in its price as compared to coal, the economics of which fuel should be used may easily

be reversed, at the same time probably accelerating any tendencies for new arrangements in the hull. Likewise, equipment for handling coal into and out of storage and for handling ash will be adapted and improved so that coal may be stored in less valuable space and so that the handling equipment will compare more favorably as regards cost and bulk with that used for fuel oil.

"So far as the firing equipment itself is concerned, efforts will continue to obtain atomizers of wider range than those now available. Probably efforts will be made to modify the grates used with spreader stokers so that ash may be discharged continuously, thus eliminating any need for shifting boiler load when cleaning flues."

Discussing some of the factors contributing to the present use of oil for firing on most American ocean-going steam vessels, the paper said:

"When vessels burn fuel oil, they may be fueled in a shorter time than those that burn coal. In fact, oil burning ships are usually bunkered while discharging and loading cargo. Thus less time in port is required for this function. This is important to those ships especially that operate on a quick turn around, such as passenger ships."

Other factors enumerated included greater cleanliness in handling oil, both in bunkering ship and in firing, lack of ash disposal problem, and fewer persons needed in firing with oil.

Coal is available at East coast ports at a lower price on heating value basis than fuel oil, but this is offset by the advantages set forth for fuel oil. The distance that coal must be transported to ports on the Gulf and Pacific coasts makes its cost there such that it is seldom able to compete with fuel oil.

The writers noted that coastwise vessels on the Atlantic coast generally are fired with coal, as are most ships in the Great Lakes traffic. The latter frequently are carriers of coal on one leg of their journeys and may be owned by companies closely connected with the coal producing industry.

#### Dust Collection

Louis C. Whiton, president of Prat-Daniel Corporation, led the discussion of the present-day status of dust collection by reviewing the principles used in the various types of equipment now available. These included: (1) the impingement or baffle type; (2) centrifugal skimmer type; (3) cyclone type; (4) electrostatic type; and (5) the combination of electrostatic and mechanical means. He stated that the performance of the centrifugal skimmer type was better than the impingement type. The cyclone type he deemed inadequate because of the centrifugal loss in large diameters and claimed that the tubular type had a higher efficiency and offered a wide variety of arrangement to suit space conditions. The electrostatic type was highly efficient in the removal of fine particles but inadequate for removal of the larger particles. He thought the answer to the problem of dust collection would be found in a combination mechanical and electrostatic method and instanced the pilot plant at the Huntley Station, Buffalo, as a step in this direction.

Many interesting slides were presented by Richard F. O'Mara (Western Precipitation Corp.) which showed

comparison curves of recovery effected by mechanical collection in differently fired units, and also fractional efficiency curves for particles above the 10 micron size. He was not alone in his contention that an overall efficiency figure, minus 10 microns, gave a good idea of a precipitator's performance.

A paper on "Fly Ash Fuel Value for Reburning" by **E. W. Bullock**, vice-president of Fly Ash Arrestor Corporation, was presented by **H. E. Macomber** (Detroit Edison Company). It was stated that in some installations the amount of combustible in fly ash leaving the furnace has been as high as 5 per cent with pulverized-coal firing and 70 per cent in stoker firing. The reburning of fly ash was particularly applicable to spreader-stoker fired installations but fly ash cinders should never be returned to the furnace under light load conditions. Nozzles should be preferably in the bridge-wall about 12 in. above the feed flow level and the carrying-air velocity should not be less than 7000 fpm.

**H. C. Dohrmann**, of Buell Engineering Company, showed a cut-away view of his company's low-draft-loss dust collector and claimed that the power required to operate such an installation was only one-eighth of that required for a comparable multiple-cyclone system. Other slides showed arrangements of single and multiple cyclones operated in parallel and standard arrangements of 2, 4, 6 and 8 cyclones. Such installations were for operation within a range of from 50 to 200 per cent of average rating.

A résumé of modifications and developments of the Cottrell process of electrical precipitation was presented by **C. E. Bever**, substituting for **L. M. Roberts** of Research Corporation. One noteworthy development was the use of aggregate in place of the original concrete plates, which resulted in a saving of at least 35 per cent of the weight.

In the discussion that followed, Ollison Craig (Riley Stoker Corp.) drew attention to a wet, or scrubber, type of equipment furnished by his company. A feature of this equipment was the use of carbon plates in place of cast-iron plates formerly used. Another discussor dealt with a wet system furnished to a paper mill which he contended effected a 99.4 per cent recovery.

Other topics discussed included the practicability of size determination of particles less than 10 microns.

### Boiler Feedwater Studies

The first paper of this group discussed "Silica Deposition in Steam Turbines," with particular reference to the hard water-insoluble deposits of silica found on the low-pressure blading in high-pressure plants. The authors, **Prof. F. G. Straub** and **H. A. Grabowski**, both of the University of Illinois, reviewed the results of laboratory tests to determine the relation between silica in the steam and that in the boiler water at various pressures, and the relationship between solid silicic acid and the silica in the steam at various pressures and temperatures. This work was supplemented by power-plant tests to throw light on the relationship between silica in the steam and that in the boiler water, and the changes occurring in the silica in the steam as it passed through the turbines.

These investigations indicate that the silica leaves the boiler as vaporized silicic acid which later crystallizes on the blades in the lower pressure stages of the turbine. When the silica in the steam is below 0.1 ppm, no appreciable deposits are found on the blading.

The authors suggest two methods of preventing these deposits, namely, the maintenance of silica in the boiler water below 5 ppm, and the removal of silica from the steam by scrubbing with pure water.

### Potassium Treatment at Windsor Station

Experience with potassium treatment on two 1350-psi, 950-F 750,000-lb per hr steam-generating units at this station, over a period of 19 months, was reported by **W. L. Webb** of the American Gas and Electric Service Corporation.

From 1941 to April 1943 these units were operated with the conventional sodium treatment, and wall-tube failures from complex alumina and silica scales were experienced. The condenser leakage was large, up to 4000 ppm, containing  $\text{Al}_2\text{SO}_4$ ,  $\text{Fe}_2\text{O}_3$  and organic matter. At times it was difficult to maintain the silica in the boiler water at a low value by blowdown, and to hold the concentrations of treating chemicals at desired values. Removal of tube specimens revealed thin hard deposits of analcite scale which could not be removed by turbinizing. Also, water-insoluble deposits occurred on the low-pressure turbine blading and resulted in reduced output.

With the adoption of potassium treatment, it was hoped to remove the old scale as well as prevent new scale and sludge from forming. Some relief was experienced, but the sludge formation appeared to be affected more by the condenser leakage than by the water treatment, and the turbine deposits continued.

In order to obtain a comparison, one of the units was then placed on sodium treatment and the other on potassium treatment. However, since doing this, condenser leakage has been improved due to river conditions and the two types of treatment have not been put to a crucial test. When the potassium-treated unit was taken off in October of this year, sludge deposits in the hoods of the steam scrubber were practically nil and the downcover tubes were substantially clean. However, considerable sludge was found in the bottom of the scrubber and in the lower boiler drum. On the sodium-treated unit, the scrubber hoods and portions of the downcomers were found to be coated and the riser tubes showed deposits of less than  $\frac{1}{4}$  in. Moreover, the potassium-treated unit had less adherent accumulation.

When both boilers were operated with potassium treatment and a potassium to sodium ratio of 2 to 1 and  $\text{SiO}_2$  to OH ratio of 0.5 (both in epm) were maintained, failure of water-wall tubes already having analcite deposits was not prevented.

In the author's opinion the seven months' period, with low condenser leakage, did not afford sufficient opportunity for adequate comparison of the two treatments.

### Experience at Springdale Station

Reporting on potassium treatment for boiler-water conditioning at the Springdale Station of the West Penn Power Company, **L. E. Hankison** and **M. D. Baker** stated that a change from sodium to potassium salts was

made in August 1942 in an effort to prevent the formation of silica scale in the boilers and to obviate deposits on turbine blading, inasmuch as the potassium silicate compounds have greater solubility than the sodium compounds at high pressures and temperatures.

This station contains three 1350-psi, 475,000-lb per hr steam-generating units and eight 360-psi, 160,000-lb per hr units. Serious trouble with analcite scale had long been experienced in the high-pressure boilers resulting in loss of tubes and some such deposits had occurred in the low-pressure boilers although no tubes had been lost.

The sodium chemicals formerly used were flake caustic soda, anhydrous disodium phosphate and alkaline sodium sulphite. Although evaporated water was employed for makeup there was both condenser leakage and evaporator carryover. The potassium salts substituted for these sodium salts were potassium pyrophosphate, potassium hydroxide and potassium sulphite. Best conditions were found when a potassium-sodium ratio of 8 to 1 or higher was maintained.

Shortly after the potassium treatment was adopted many failures of the monel-clad asbestos handhole gaskets appeared. Investigation showed that while there had been no such leaks when the sodium treatment was employed, the sodium deposits had caused the leaks to be self-sealing; and the potassium treatment had dissolved these deposits. After re-gasketing and re-rolling tubes this trouble disappeared.

From the second to the sixth month of the potassium treatment the amount of  $\text{Fe}_2\text{SO}_4$  in the boiler deposits gradually increased. Also, instead of a soft powdery deposit in the tubes, pieces of iron oxide scale ( $\text{Fe}_2\text{O}_3$ ) were found. This loose scale increased until it finally became necessary to shut down the boiler for cleaning. The explanation offered is that a layer of analcite scale had formed over large areas in the water-wall tubes when using the sodium treatment and that the potassium had leached out the silica, made the scale porous and caused the iron oxide scale to loosen.

The pH values were lowered to 10.0 or 10.5 to reduce the  $\text{Fe}_2\text{O}_3$  and after two months the sludge in the boilers had changed from a soft powder deposit to many small pieces of scale. Also, the tubes were coated with a deposit resembling a hard dried sludge, the color of the deposit having changed from black to gray. Because of this condition, alkalinities were again raised to the former levels and the deposits soft and nonadherent. When the alkalinities were raised, potassium chloride was added to the boiler water to prevent caustic attack.

Potassium sulphite was discontinued in September 1943 as the small amount of oxygen present in the feedwater could only affect the economizers and these were protected by recirculation of the boiler water.

During the first four months of 1944, however, heavy sludge deposits, resulting from severe evaporator carryover, and the presence of lead-compounded oil in the feedwater caused a number of tube failures.

The authors' conclusions were that when using potassium treatment all surfaces where sludge does not accumulate are clean; whereas with the sodium treatment a film of silica scale was often present. While potassium silicate will not deposit as a scale, potassium aluminum silicate and potassium iron silicate will

form under sludge deposits where the boiler water can concentrate. However, indications are that amount of scale is not as heavy with potassium as with sodium and the potassium scales will disintegrate with hydrochloric acid. When the epm ratio of potassium to silica is less than 8 to 1, the condition of the interior of the tubes is similar to that found when using sodium treatment.

Furthermore, when the carryover exceeds 0.3 ppm (normal for Springdale), some water-insoluble turbine-blade deposits will occur. When employing sodium treatment the silica turbine-blade deposits had to be sandblasted, whereas since using the potassium treatment water washing of the turbine has been found to restore 90 per cent of the lost capacity.

## External Corrosion of Furnace-Wall Tubes

The external corrosion of furnace-wall tubes of slagging-bottom furnaces became a recognized problem to operators and boiler manufacturers early in 1942. It prompted numerous field investigations and, as a result of which certain expedients were adopted to combat this phenomenon. However, with a view to ascertaining the true cause and the mechanism of such corrosion and, therefore, the proper corrective measures to be adopted, a cooperative research program was undertaken by Combustion Engineering Company and the U. S. Bureau of Mines at the latter's laboratory in Pittsburgh, supplemented by further field investigations. The results to date formed the subject of two papers by W. T. Reid,<sup>1</sup> B. J. Cross<sup>2</sup> and R. C. Corey,<sup>3</sup> the first dealing with the "History and Occurrence" and the second with the Significance of Sulphate Deposits and Sulphur-Trioxide in Corrosion Mechanism."

The "enamel" deposits found on the tubes in areas where external corrosion occurs are greenish-white to reddish-brown in color and are soluble in water, in which they produce an acid reaction. X-ray diffraction studies show them to consist primarily of a solid solution of sodium and potassium sulphates and alkali metal ferric trisulphates, such as  $\text{K}_3\text{Fe}(\text{SO}_4)_3$ . Experiments under controlled laboratory conditions with actual and synthetic "enamels" have shown that at temperatures of 1000 F, sodium and potassium sulphates will react readily with iron oxide in an atmosphere containing a low concentration of sulphur trioxide to form the same alkali metal trisulphates as occur in the "enamels." However, under the same conditions of temperature and concentration of  $\text{SO}_3$ , neither iron oxide nor the alkali metal sulphates alone will react with  $\text{SO}_3$ .

These reactions suggest the mechanism of corrosion to involve the removal of the normally protective oxide on the furnace tubes by (a) the condensation on the relatively cool tubes of alkali metal oxides which are converted to the corresponding sulphates by the  $\text{SO}_3$  in the furnace, and (b) the subsequent reaction of the iron oxide on the tubes and the alkali metal sulphates with the  $\text{SO}_3$ , evolved as the result of the slagging reactions in the coal ash deposited on the "enamel." Thus conditions are afforded for the removal of the iron oxide on

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the tube with the formation of alkali metal ferric trisulphates. Deslagging causes thermal decomposition of these compounds and the cycle is repeated.

One suggestion is that prevention of corrosion by this process may be achieved by ventilating the surface of the tubes with air so as to decrease the concentration of  $\text{SO}_2$  below that necessary for the formation of the complex iron sulphates. Also, because the alkali metals required for the reaction are believed to originate principally from the flame, the addition of such air decreases the rate of deposition of alkalies. This is in agreement with field observations in which the maintenance of oxidizing conditions near the tubes by means of burner changes or air-belting prevented further corrosion. The rôle of such air is considered to be that of a diluent and the fact that carbon monoxide disappears in the process is not in itself important.

However, the investigation is being continued and a further phase will deal with a study of the sulphides and with protective coatings. It is planned to report these findings in a future paper.

### Measurement of Heat Absorption

A symposium dealing with various methods of measuring heat absorption in furnaces was made up of twelve papers divided into two groups, namely, applications to boiler furnaces and applications to industrial furnaces; or, as stated by **B. J. Cross**, who was largely responsible for the program, the division was made as to those furnaces in which useful heat is absorbed by the furnace walls and those in which heat is given up by the walls to the product being heated. Only those papers dealing with boiler furnaces will here be reviewed.

The first speaker, **Dr. H. F. Mullikin**, discussed the overall heat absorption of a furnace by measurement of the gas weight and temperature at the furnace outlet. In this he described the generally accepted method of determining the heat content of gases leaving the furnace by means of a high-velocity aspirating thermocouple and the sampling of gas at the area traversed for temperature measurement. The heat input to the furnace must be known and the heat absorbed determined by difference.

**A. A. Markson**, of Hagan Corporation, dealt with pyrometric measurement of boiler furnace radiation; that is, the measurement of radiant intensities in water-cooled boiler furnaces by use of instruments sighted through available observation ports. The significance of the angle of view was discussed as well as the types of instruments most suitable for such work. He also described an expansion radiometer of novel design.

Use of a calorimeter for measuring total heat absorption at local areas of a furnace was discussed by **R. C. Patterson**, of Combustion Engineering Company. These small heat-absorbing elements are so installed as essentially to form a part of the wall but with separate feed of water so that the total heat absorbed may be measured. The method of construction and installation was described, test procedure given and typical results cited. Also, heat absorption rates were compared with surface metal temperatures measured on adjacent tubes.

**F. G. Ely**, of Babcock & Wilcox Company, dealt with the use of measured metal temperatures and tem-

perature gradients of the tube wall to determine the rate of heat transmission to the fluid. He discussed and illustrated features of several types of thermocouples installed in steam-generating tubes exposed to furnace radiation, both for the measurement of tube metal outer-surface temperature and of temperature gradients existing in the tube wall. Data were also presented showing evidence of low thermal resistance at the inner surface of a clean generating tube having positive circulation. Such data offer a means for determining local heat absorption rates, as well as for detecting the presence of scale deposits on the inner surface of the tube.

**A. R. Mumford**, of Combustion Engineering Company, concluded that part of the symposium dealing with boiler furnaces by discussing the evaluation of tubular heat receiving surfaces located in or forming on furnace walls in terms of plane surface. On the assumption that the film resistance on the inside surface of a boiler tube is negligible in comparison with the temperature drop through the metal, he suggested that the determination of the distribution of temperature drop through the heat-absorbing surface provides a measure of the amount of heat absorbed. A comparison of two types of furnace-wall construction was made on the basis of external surface temperature distribution. The method was proposed as a technique for testing the effectiveness of different wall-cooling constructions.

### Post-War Power Problems

This formed the subject of a Panel Discussion on Tuesday evening, the participants being **T. G. Le Clair** of Commonwealth Edison Company, Chicago; **E. B. Ricketts** of Consolidated Edison Company, New York; **P. W. Thompson** of The Detroit Edison Company; **F. M. Gibson** of the American Sugar Refining Company; and **E. G. Bailey** of Babcock & Wilcox Company; with **T. E. Purcell**, of the Duquesne Light Company, acting as Chairman.

**Mr. Le Clair** pointed out that the electric utility industry has a high investment per dollar of output and that, unlike many other single industries which can predicate their post-war plans on probable conditions and trends in their own fields, the electric utilities must consider a cross-section of many industries that make up their customers. Moreover, the time involved in design and construction makes it necessary that planning be two or three years in advance of demand.

The latest available overall figures for the entire country show approximately 70 per cent of industrial power to be purchased. This class of load has increased nearly four times in the last ten years; residential demand has increased at a steady but lower rate; and commercial load has declined during the war period. It has been estimated that reversion from wartime to standard time may add  $1\frac{1}{2}$  million kilowatts to the combined peak demand. This, however, will have the effect of lowering the present high load factor under which the utilities are operating.

The speaker showed slides of curves representing four different post-war surveys made by companies operating in different sections of the country. The highest estimated a 16 per cent increase in the third or fourth post-war year, whereas the lowest estimated it would

take that long to get within 6 per cent of the present load. This discrepancy may be accounted for by the probable geographical shift from wartime to peacetime production.

Mr. Ricketts expressed the opinion that the post-war pent-up demand for power would gradually taper off but that loss in net income of the utilities would be small. A problem for the utilities will be, how to continue the downward trend in production cost in the face of increased fuel prices and higher hourly labor rates. Despite this, it seemed likely that the item of labor per kilowatt-hour output could be decreased. He believed that changes in equipment would come slowly and that post-war power practice would not differ greatly from that of the pre-war period.

Mr. Thompson confined his remarks largely to power plant betterments which he divided into two groups, namely those having to do with increased economy and those essential betterments associated with maintenance which must receive first consideration. Those of the first group have been generally absent from budgets during the last three years, but will demand attention in the post-war period. He said in part:

"Each dollar of annual maintenance and operating expense saved by betterments made to electric power systems will balance about \$10 of the required capital expenditure. It should be remembered, however, that once the capital investment is made, the annual charges against it go on year after year, regardless of business or load conditions. Where maintenance costs are excessive, capital investment to offset them may be safe; but the savings to be effected by the mere substitution of new or higher priced equipment may be problematical. Also, operating costs vary in part with the load and in lean years operating savings due to capital investments may be much smaller than originally anticipated. However, a countervailing factor in both cases is the likelihood that labor costs may go higher.

"Expenditures for betterments to improve reliability are particularly difficult to appraise. In the generating station the decision may be more a matter of judgment than the result of experience. In the case of transmission and distribution, however, the records of past outages and failures may point very definitely to the need for improvement."

Speaking for the industrial power plant, Mr. Gibson was of the opinion that although the resumption of civilian production curtailed by the war together with increased export trade, would provide an excellent load factor, this will gradually taper off and there is little indication that such demand will warrant an appreciable investment in increased generating capacity.

Most post-war planning concerns the replacement of worn-out and inefficient power plants and the volume of such replacement will exceed that of the pre-war period. It will likely apply largely to those plants in which there is a high power use per unit of production and less will be done in plants of relatively small power demands where available funds will go first into new manufacturing and process equipment.

It is anticipated that after the war, industry will install new processes, and the general trend will be to reduce the heating load and increase the power load which will be further increased by additional labor-saving equipment because of rising labor rates. This will

likely result in the unbalancing of the steam system which will have to be met by new power plants or topping, or the changing of motive power of auxiliary and general service equipment.

Mr. Bailey was of the opinion that major reliance of industry for power production in the post-war period will continue to be placed on steam, despite developments in diesels and gas-turbine units for special applications and within certain limits of size. Moreover, there will be no startling developments awaiting the power engineer at the close of the war and the post-war plant will not be essentially different from that built immediately preceding the war, except perhaps involving higher costs. He cited some interesting figures showing that while the present installed capacity in stationary plants of all types is now approximately 61 million kilowatts the capacity now installed in U. S. naval vessels of all types is 96 million horsepower, made up of 44 million horsepower in steam and 52 million horsepower in diesels. The latter covers innumerable landing craft and small vessels.

While steam power equipment can now be had in any desired size of unit up to a million pounds of steam per hour for any pressure up to 2400 psi and steam temperatures up to 950 F, and with reheat up to an equal temperature, the speaker did not anticipate any rapid trend toward higher steam pressures than those now generally employed, nor toward reheat until economics justify them; but he does believe that steam temperatures will gradually trend upward to 1000 F or perhaps 1050 F as experience and economics dictate.

The principal accomplishment of the past decade has been in steam-generating units designed for multiple fuels and for lower grades of coal. Experience obtained during the war with units more sensitive to departure from the use of the better grades of coal should teach power engineers the lesson of having a reasonable latitude in all features of power plant design.

Except for a trend toward higher fuel costs, Mr. Bailey did not believe that the fuel situation in the immediate post-war period would be materially different from that of the pre-war period, but that the long-range trend will be toward less oil for steam power and that the available coal will gradually become lower in ash-fusing temperature with the quality more varied in different parts of the country than it has been in the past.

Finally, improvement in the use of coal in the small steam plant is long past due and as a result he predicted that there is likely to be greater activity in this field.

### Discussion

In the general discussion that followed, it was pointed out that, whereas in the past many private power plants had been shut down in favor of purchased power, there is now a trend toward putting more technically trained men in positions of power supervision and in the future we may look for increased economy in the operation of the smaller plants. It was agreed that the larger industrials, especially those having uses for large quantities of process steam, would continue to generate their own power. However, the fact remains that in most industrial plants there is keen competition between various departments for funds that may be available for

improvements and in this respect the power department often suffers. This is particularly true where the cost of power entering into the cost of the manufactured product is relatively small.

As to the possibilities of the gas turbine, it was generally agreed that, despite the development work that has been going on, this form of power production is still some distance off as concerns the utility field, although it offers some possibilities in relatively small capacity when placed at the end of a transmission line. Many installations have been made in oil refineries, and the railroad and marine fields offer possibilities. One present limitation of the gas turbine, however, is its relatively poor efficiency at light load. It was shown further that although such equipment was associated with very high temperatures, the actual temperature of the gases entering the turbine blades is comparable with that of the steam turbine, namely, around 900 F; hence no problem in turbine blading material is involved.

### 10,000-Kw Power Trains

Two 10,000-kw power trains constructed by the General Electric Company for the Navy Department were described in detail in a paper by **Edwin Lundgren**, Senior Mechanical Engineer of the Bureau of Yards and Docks and by **L. R. Biggs** of the General Electric Company.

These mobile power trains were built with the idea of helping to make up shortages of power that might occur at any of the naval land establishments, or supplementing central station supply where necessary in localities furnishing materials for the Navy, or of supplying temporary facilities in the event of interruption of power supply by air attack in a critical area. One of the trains is now supplying additional power at a naval base on the Pacific Coast and the other is supplementing service from a central station in the South during an emergency shutdown.

Each train consists of six cars. The boiler car carries the main steam boiler, the boiler feed pumps, forced-draft fan, deaerating heater, fuel tank and pumps, air compressors, water tank and an auxiliary boiler. The turbine car carries the main turbine-generator, condenser, evaporator, 350-kw auxiliary turbine-generator,

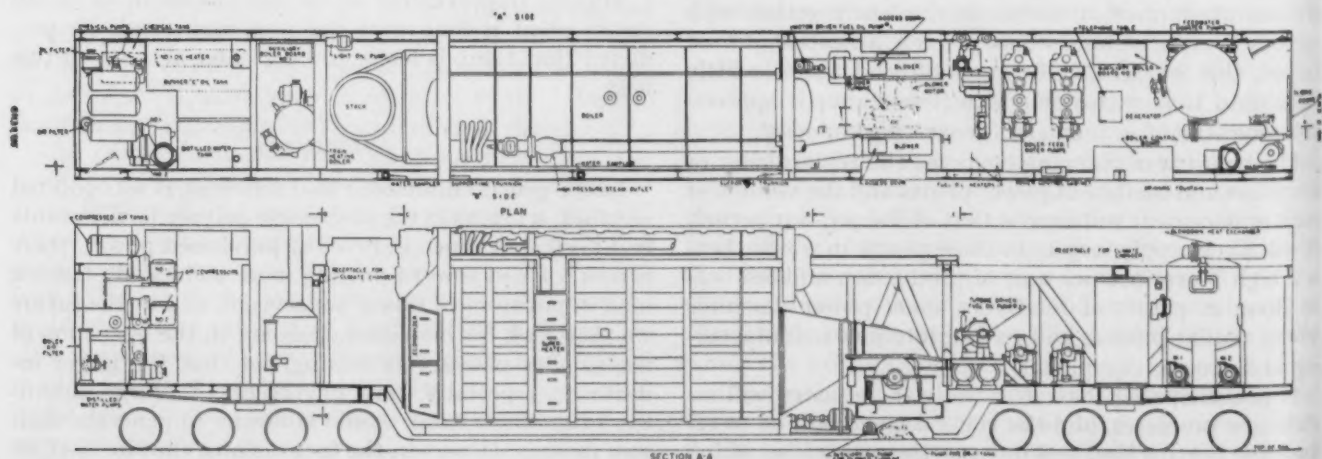
water-chilling equipment, lubricating-oil tank and surge protectors. On the switchgear car is mounted the main and auxiliary equipment, a 50-kw diesel-driven generator, exciter set, storage battery, chemical laboratory and cable reels. The transformers and gas-sealing equipment take up the fourth car, and the fifth car mounts the circulating-water pump and motor, the strainers and suction hose, hose for the circulating water and the fuel-oil piping system. A box car contains the raw-water pump and hose, fuel-oil transfer pumps, oil hose, air-conditioning equipment, work benches, lockers, tools, etc. A track length of 386 ft is taken up by the six cars which will be increased by the addition of other cars and the locomotive when in transit and the maximum design speed was 40 mph. The location of equipment in the boiler and turbine cars is shown in the accompanying illustrations, from which an idea of the compactness may be gained.

Special bracing of the cars was necessary to take up the shock of braking. The boiler is suspended from steam drum, the weight being carried to the side trusses of the car by trunnions. The front trunnion is anchored to absorb the shock when the car is braked, stopped or started. The rear supports allow for longitudinal expansion of the drum.

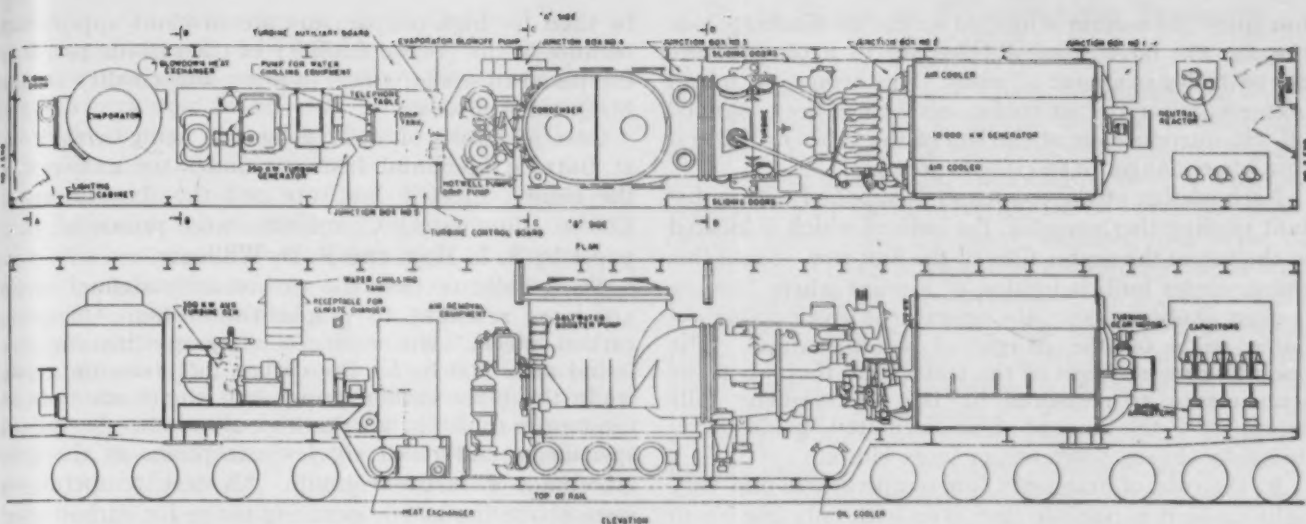
The boiler, of B & W design, is of the single longitudinal drum, natural-circulation type with completely water-cooled oil-fired furnace and is designed for normal output of 120,000 lb of steam per hour (140,000 lb maximum continuous) at 560 psi and 825 F at the superheater outlet, with feed to the economizer at 220 F. At the rated output 100,000 lb per hr passes to the main turbine and 20,000 lb per hr is utilized by the auxiliaries. Steam for the auxiliaries is desuperheated to 650 F. At rated capacity the heat release rate in the furnace is 416,000 Btu per cu ft, combustion air being delivered to the two forced-draft fans at around 320 F after passing over banks of finned tube downcovers extending between the steam drum and the water-wall headers.

Steam-mechanical atomization is employed, using five burners. The steam is supplied to the burners at oil pressures up to 100 psi above which straight mechanical atomization is used.

The combustion gases flow horizontally, parallel to the steam drum, through a water screen and then five



Plan and side elevation of boiler car



Plan and side elevation of turbine car

rows of closely spaced boiler tubes before reaching the superheater; then to the economizer and the stack which is of telescopic design. No induced draft is used.

The auxiliary boiler is of the Vapor-Clarkson recirculating type and provides initial steam for fuel-oil heating, for heating the train and for supplying steam for oil atomization in the main boiler when placing the plant in operation.

The main electric generating unit consists of a single cylinder 10,000-kw, 14-stage, 3600-rpm G-E turbine operating with steam of 550 psi, 825 F at the throttle, 3 in. Hg abs at the exhaust, and connected to a 12,500-kva, 13,800-volt three-phase, 60-cycle generator.

The condenser is of vertical design and the arrangement departs from usual practice in that steam flow in the turbine is away from the generator instead of toward it. No steam extraction is employed as this would have complicated the layout in the limited space available.

Operating data from a 77-hr 45-min test gave the following plant performance at various outputs:

Name of run	Corrected net	Time	Heat rate,
in kw	output, kw	Hr Min	Btu/kwhr
1,500	1,250	37 15	25,200
2,500	2,150	6 15	18,640
5,000	4,500	3 00	17,560
7,500	7,500	5 30	17,570
10,000	9,850	5 30	18,400
12,500	12,093	3 30	

A test was conducted to determine the time required to place the mobile power plant in service after it arrived at a certain location. Two locomotive cranes and a total crew of 40 men, including the specially trained skeleton crew assigned to each mobile power plant, could locate and start the plant within 8 hr.

## Air-Cooled Steam Condensers

R. A. Bowman, of Westinghouse Electric & Mfg. Co., described the air-cooled steam condensers employed on the Power Trains<sup>1</sup> recently shipped to devastated regions abroad. Because of the various areas in which

<sup>1</sup> For a description of these trains see COMBUSTION, July 1944.

these trains were likely to be employed, they were designed to operate at ambient temperatures ranging from 40 deg below zero to 95 deg above. The prime purpose of the condensers, which are mounted on two cars, is to recover condensate rather than to reduce the heat rate of the plant by production of a vacuum. In fact, the condenser size and power requirements of the blowers would have been excessive if a vacuum of any magnitude were desired.

For the 1000-kw trains, the condenser on each car is made up of eight sections with air supplied by four propeller-type blowers. Steam enters at the bottom, is condensed, and the condensate drains back into ducts from which it is removed by a condensate pump. This counterflow relationship was chosen not only as it serves to heat and deaerate the condensate but as it also prevents freezing.

The condensing sections consist of ten rows of steel tubes with spiral fins, mounted vertically, and galvanized inside and out. In order to supply each section with the steam required, each tube bank is divided into five groups of two rows each, the first four groups exhausting through orifices into the fifth group which serves as the final condensing section. The orifices limit the amount of steam which any group can supply to the fifth group, or "air cooler," thus providing an adequate balance of steam flow. This arrangement for supplying all the tubes in accordance with their capacity to condense serves to keep all areas warm and free from ice when operating at light loads and very low temperatures.

Under conditions of light load and cold air, the vacuum determined from heat transfer considerations will exceed that produced by the ejector, and the condenser will begin to fill with air until the point is reached at which the remaining surface supplied with steam is just sufficient to satisfy the heat-transfer equation. As soon as a tube fills with air its temperature will drop to approximately that of the air outside the tube. If this temperature is below the freezing point, all water in the condensate which is formed within the tube or flows into it from other sections will freeze. The first tubes in which this will occur are those in the air cooler section;

but since this section is located on the air discharge side the air will have been warmed up to a temperature above 32 deg in almost all cases. Any reduction in load occurring after the air-cooler section has been blanked off will introduce air at the top of the tubes in the first row where danger of freezing is great.

Each section of the condenser is supplied with a distant reading thermometer, the bulb of which is located in the top of the center tube of the first row. Since this thermometer bulb is located at a point where freezing is most likely to occur, the operator is given a very reliable guide on the danger of ice formation. The operating instructions of the train state that when the temperature as measured by this thermometer falls below 150 F the amount of air circulated should be reduced by closing down one or more blowers.

In the case of extremely low temperatures and very light loads, it is possible that even with only one car in service and one blower operating on that car that the temperature as read on the thermometer will still tend to fall to a dangerous degree. To provide for such an eventuality, the condensers are equipped with cover plates which can be used to cover a part of the surface of each section to reduce the cooling area and the amount of air flowing.

### Graphitization of Steel Piping

Failure of steam piping at the Springdale Station of the West Penn Power Co. early in 1943, instigated investigations in other plants to discover the cause of graphite formation in carbon molybdenum pipe and welded steam lines. The results of these investigations were presented under the auspices of a Joint A.S.T.M.-A.S.M.E. Research Committee on "Effect of Temperatures on the Properties of Metals."

In a paper presented by **H. J. Kerr** and **F. Eberle** (Babcock and Wilcox Co.) it was stated that abnormal low-carbon steel with normal heat treatments graphitizes at temperatures from 850 and 1020 F with reasonable stress. Low-carbon steel, with normal grain size of 1 to 5, under identical conditions for almost nine years was found free of graphite in both the weld-affected and unaffected metal. Welding abnormal steel produced little if any localized effect. In some cases carbon-steel weld metal has graphitized, in other cases it has not.

Molybdenum exerts a definite resistance to graphitization. Normal and abnormal carbon-molybdenum steels show slight, if any, graphite after 5½ years' service except where the abnormal steel has been subject to heating and cooling. Repeated applications of the heating and cooling cycle promote graphite formation at the subcritical temperature of 1000 F, and increased rates favor the formation of chain graphite. Normal carbon-molybdenum steels subjected to the heating cycle are not found graphitized in service at 975 to 990 F; abnormal carbon-molybdenum steels in the same pipe line have graphitized severely.

The McQuaid-Elm test is a valuable criterion of the graphitizing tendency of carbon and carbon-molybdenum steels. On the basis of the studies made, it is recommended that coarse-grained normal carbon-molybdenum steel with 0.4 to 0.6 per cent chromium

be used for high-temperature steam plant application because of the greater stability of the carbide phase as compared to similar steels showing abnormality on the McQuaid-Elm test.

Current results of an investigation being carried out at Battelle Memorial Institute under the auspices of the Edison Electric Institute and the Association of Edison Illuminating Companies, were presented in a paper by **S. L. Hoyt** and **R. D. Williams**.

Tests indicate that the carbon-molybdenum steels are more resistant to graphitization than the plain carbon steels. No evidence of graphitization was found after 500 hr for the carbon-molybdenum group while the plain carbon group had slight amounts of random graphite in all the high-aluminum deoxidized specimens, and relatively few exceptions in the low-aluminum deoxidized group. All test temperatures were above the usual operating range for carbon steel pipe, but the appearance of slight amounts of graphite at 925 F is significant because this temperature is comparable to 1025 and 1125 F for carbon-molybdenum steels. After 1500 hr very considerable amounts of random graphite were present in many of the plain carbon-steel specimens, whereas in the carbon-molybdenum specimens, small amounts of graphite were found in the high-aluminum deoxidized type only.

In all cases where graphite was observed, steels deoxidized with 1.5 to 2 lb of aluminum per ton had more graphite than those deoxidized with approximately ½ lb of aluminum per ton. In some instances no graphite was found after 3000 hr in low-aluminum deoxidized specimens, while moderate amounts were found in high-aluminum deoxidized specimens subjected to identical test conditions.

Segregation of graphite at the weld-affected zone was found in plain carbon steel (3000 hr) but has not occurred in the welded carbon-molybdenum steels after 5000 hr. All graphite in unwelded specimens is distributed at random.

Current test results have not established too clearly the effect of prior structure on the susceptibility of a steel to graphitization. Results so far indicate that specimens stress-relieved at about 1300 F are, in general, slightly more susceptible to random graphitization than those stress relieved at 1200 F.

### Investigations at Detroit

The results of an investigation of graphitization made by The Detroit Edison Company were presented in a paper by **R. M. Van Duzer, Jr.**, **I. A. Rohrig** and **A. McCutchan**.

Carbon-molybdenum creep-test pipe sections showed no graphite after 20,000 hr at 925 F. A few dispersed nodules of graphite were found in a carbon-molybdenum casting from the Delray installation after 15,000 hr at 1000 F. No serious graphitization was found in any of the six carbon-molybdenum and nine carbon-steel pipe joints examined after service at 900 F and at 835 F, respectively. The greatest amount of graphite was found in a carbon-steel pipe joint after 64,000 hr at 835 F. No graphite was found in the low-aluminum variety of carbon-molybdenum pipe joints in service at 900 F for periods up to 20,000 hr.

Creep tests indicated that the carbon-steel weld metal had decreased in creep strength due to service

at 835 F; the creep strength of the Grade B carbon-steel pipe appeared to be unaffected by service. Temperature variations of 30 F above nominal design temperatures were found to be of common occurrence, although average operating temperatures were at, or below, the design temperatures.

The laboratory findings confirmed the greater graphitization resistance of welded low-aluminum carbon-molybdenum pipe material and the advantages of normalizing welds as a preventive of graphitization adjacent to welded joints.

In presenting a study of austenitic welding for control of graphitization, **I. A. Rohrig** (Detroit Edison Co.) claimed that austenitic chromium-nickel filler metal readily absorbs carbon and that this characteristic results in the removal of carbon from the heat-affected area of the pipe metal. Furthermore, it was strongly indicated that such filler metal will inhibit the formation of dangerous chain-type graphitization in the critical zone during high-temperature service. In carbon-molybdenum pipe such welds have good strength, ductility, notch-toughness and creep strength and require no heat treatment after welding. It was also suggested that this welding procedure may be particularly adaptable to the re-welding of joints at which serious graphitization has been found to occur in service.

**George A. Timmons** (Climax Molybdenum Co.) presented an interesting paper in which graphitization of carbon-molybdenum steel pipe in high-temperature steam installations is considered from the viewpoints of thermodynamic stability and rates of reaction.

Cementite is not stable below 1490 F but graphite is, so graphitization may be expected whenever cementite is present in a steel placed in service at 850 to 1000 F. Factors which accelerate graphite nucleation shorten the service life of a steel and factors which retard graphite nucleation lengthen service life, but to date the only positive method of preventing graphitization is to exclude carbon from the steel. This is now commercially impractical. However, by restricting the carbon content to less than 0.06 per cent, the amount of graphite that can be formed may be so limited that it would be ineffective. It is proposed that iron-base alloys containing less than 0.06 per cent carbon and alloyed to provide adequate creep strength be given further consideration as materials for high-temperature steel piping.

**G. V. Smith** and **Miss S. H. Bramber** (U. S. Steel Corporation of Delaware) presented a report on a study of weld samples and of end-quenched samples of 0.15 to 0.80 per cent carbon steels, and of low-carbon 0.50 per cent molybdenum steels. Metallographic examination was made after 1000 and 2000 hr at 975 F, and after 2000 hr at 975 F plus 1000 hr at a temperature of 1050 F.

With the weld samples, the effect of variations in type of steel, treatment, speed of welding and heat treatment after welding, showed that localized graphitization occurred in the heat-affected zone at a relatively rapid rate on molybdenum steel; also that this graphitization was prevented in a companion section by treating the affected portion for four hours at 1300 F prior to exposure at 957-1050 F.

## Plate Sizes in Fabricating Pressure Vessels

By selecting plate sizes which eliminate extra seams and shop operations incidental thereto, considerable savings in costs may be effected by the engineering department of a company fabricating boilers, pressure vessels and similar structures, **Dr. W. G. Theisinger**, of the Lukens Steel Company, declared in a paper on "Fabrication Costs of Boilers, Tanks and Pressure Vessels as Affected by Plate Widths."

In order to determine the size of plate best suited, the extra cost of fabrication where a number of plates are involved, must be compared with the width extra costs charged by steel mills for wide plates. For plates greater in width than 100 in., an extra price is charged by the industry in increasing amounts up to 195 in. (which is approximately the widest carbon-steel plate that can be obtained). On the other hand, if the vessel is to be constructed of a number of plates of less than 100 in. in width to avoid width extras, the additional fabrication resulting from the extra courses required, may be extremely expensive in cost, production time and manhours.

When the difference in cost is slight, so that either wide or narrow plates may be used, the manpower available or the production schedule, or both, may be the deciding factor.

## Education and Apprenticeship

College courses, designed specifically for the engineering student, that would include some elements of a liberal education, were advocated by **Dean Clement J. Freund** of the University of Detroit. To achieve this aim the faculty at the University of Detroit has made 200 course revisions. Supplementing the so-called cultural subjects, particular emphasis is to be put on the history of engineering, the place of engineering in society, and career opportunities.

In the views expressed by **Mark Ellingson**, President of Rochester Institute of Technology, the initiative has passed from the cultural colleges (where only 25 per cent of students enrolled are actually graduated) to institutions specializing in technical education. Since the education offered by such institutions is functional and practical, they would answer to the needs of returning veterans. He cited the program of State technical institutes proposed by the State of New York as typical of the thinking of educators throughout the nation. These institutes will serve a neglected need in American business and industry. For every engineer who is graduated, four or five skilled artisans are required to carry out his ideas. Technical institutes fit in with the general theory of democracy that an individual can begin at the bottom and work up just so far as his capacities and abilities will take him.

**William P. Patterson**, director of the apprenticeship-training service, War Manpower Commission, stressed the interdependence between the mechanical engineer and skilled workman, and stated that the training of skilled labor was a responsibility of industry, not of Government. In the post-war period manufacturing and construction industries will require continuous apprentice training of 619,000 workers. Of this num-

ber 106,000 must be graduated annually to full-fledged craftsmanship and 220,000 additional employed each year. These figures (based on 1940 employment) do not allow for any increase in the number of skilled workers after the war. Since only a fraction of the required number of apprentices has been trained during the war, there will be opportunities for many thousands of veterans who will want to take advantage of such training. American industry must concentrate as never before on the task of building up and maintaining the ranks of skilled workers through apprentice training.

About 20,000 plants participate in the national apprenticeship program and labor unions are cooperating wholeheartedly. But that is only a beginning, because the number of establishments with facilities to set up apprenticeship systems total 439,000.

### Engineers of Tomorrow

The topic chosen by **President R. M. Gates** for his presidential address at the Annual Dinner was "Engineers of Tomorrow." Presenting this in brief, he envisioned future engineering requirements as involving five general assumptions, namely, specialization without isolation, character as well as knowledge, acquaintance with the whole industrial process, adjustments in human relations, and extension of educational opportunity.

He pointed out that the changes fostered by engineers have been made against a background of slower-

changing human nature and that our civilization can advance only as the adjustments in human relations keep pace with, or do not lag too far behind, the changes in our environment. While the nature of our civilization and our daily life is being changed by science, engineering and industry, we must keep open the door of individual opportunity. Continuing he said:

"As the horizons widen, as new frontiers open, what engineering students, when they become engineers, will do in the post-war world seems to involve far greater opportunities and responsibilities than ever before.

"Engineers cannot be isolationists, as far as the traditional branches of the profession are concerned. Few of us in practice can be mechanical engineers alone; we have to learn something of civil, electrical, chemical engineering and other branches in order to do intelligently and completely all the jobs entrusted to us. A large percentage of engineering graduates do not follow the type of engineering in which they specialized at school, but it is the fundamental techniques and disciplines they acquired that have been more important to them than early specialized training.

"Many engineers are called upon to assume major responsibilities in industrial management, and in the years ahead one may expect that management of industry will be recruited more, rather than less, from our profession. The application of engineering techniques and the engineering mind, to a broad field of post-war problems, not only here but in other countries, will surely be needed; and with these prospects, isolationism must not accompany the necessary specialization in engineering education."



**Group at the Annual Dinner and Honors Night**

Left to right—President-elect Alex D. Bailey; President Robert M. Gates; Lillian M. Gilbreth, recipient of the Gantt Medal; Ralph E. Flanders, recipient of the Hoover Medal; and W. L. Batt, Toastmaster

# Feedwater Treatment for High-Pressure Boilers at Dow Chemical Company

With these 1400-lb units essentially all the feedwater is chemically treated external to the boilers, phosphoric acid and caustic soda being fed to the hot-process softener. By this means outage for cleaning tubes has been practically eliminated, the first unit having operated for 22 months with no indication of accumulated deposits and the second unit showing only 25 grams after nine months of operation. The high-pressure boilers are blown down to the drums of the 400-lb boilers.

**I**N 1937 The Dow Chemical Company installed a 300,000-lb per hr 1400-psi boiler and a 1250-psi turbine-generator to be superimposed upon their existing 400-psi installation. A second boiler, and provisions for a second generator, similar in capacity and design, were installed in 1942. These two installations were not interconnected and the individual boilers and the turbine operate as single units. Each of these boilers was equipped with steel-tube economizers. These installations were made to meet increasing demands for power.

While the 400-psi boilers were fed with zeolite-softened water and condensate from industrial evaporators, it was recognized that this water would not be satisfactory for the 1400-psi boilers, and condensate from the industrial evaporators, available in considerable quantities, was used along with condensate from condensers, etc.

The condensate from the industrial evaporators was contaminated with various salts, principally calcium chloride, magnesium chloride, sodium hydroxide, sodium chloride and calcium carbonate, resulting from carryover and leakage. This was not considered excessive as the contamination never exceeded approximately 15 ppm.

This water was as good, or better, than the effluent of a hot-process water softener utilizing lime and soda ash as the treating agents, and not appreciably higher in calcium and magnesium than the average effluent of a zeolite softener. Because of this, internal treatment with phosphate was considered adequate at the time the first boiler was placed in service. Initially, therefore, the water was conditioned by deaerating the boiler feed supply, using an atomizing type of deaerator, and proportioning caustic soda continuously ahead of the economizers. Mono-sodium phosphate was injected intermittently into the boiler for pH and sludge control.

With this type of treatment the sludge accumulations in the boiler tubes of the first boiler were quite heavy and these deposits could only be removed by chemically cleaning or by turbinizing. At pH values above 11, the sludge

By L. F. Wirth\* and C. E. Joos†

consisted of a complex sodium calcium phosphate of the following composition: 4 mols sodium (Na);  $5\frac{1}{2}$  mols calcium (Ca); 6 mols phosphate ( $\text{PO}_4$ ); some hydroxide (OH) and water of crystallization. At pH values of 10 to 10.5 the hydroxy apatite  $[\text{Ca}_{10}(\text{OH})_2(\text{PO}_4)_2]$  was formed.

The accumulation of sludge in the boiler tubes was such that it was necessary to take the boiler off the line for cleaning at intervals of 90 days, although no external repairs to the boiler, or inspections of the furnaces or generator were required at those times. This outage represented a serious loss of electrical energy, because the generator was made inoperative when the boiler was taken out of service.

In order to eliminate this outage for boiler cleaning, further study was made to improve the character of the feedwater so as to prevent the deposition of sludge. Consideration was given to the removal of the contamination external to the boiler, because of the failure of various internal treatments to render the sludge nonadherent.

The contaminated condensate was delivered to the power plant at a temperature of 150 to 165 F. The zeolite process could not be considered, as the limiting temperatures for satisfactory operation for practically all types of zeolite material, is 100 to 120 F. Resinous ion-exchange material was then in the development stage and was not considered satisfactory for high temperature use. Zeolites tend to disintegrate or discharge color with higher water temperatures.

The hot-process softener, utilizing lime and soda ash as the treating reagents, could not be considered because of the inability of these reagents to reduce the hardness appreciably, except by the addition of prohibitive excesses of soda ash. The only alternative was to treat with phosphate in a hot-process softener. With this treatment, hardness could be precipitated to practically zero without appreciably increasing the solids or alkalinity, and, because of these features, it was considered the best means available. Accordingly, two Cochrane deaerating hot-process water softeners were installed, one for each boiler-unit. The first unit was designed for the heating, deaerating and treating of 32,000 gal per hr of contaminated condensate, and for heating and deaerating 12,000 gal per hr of pure condensate. The second unit, handling only the contaminated condensate, was designed for a capacity of 44,000 gal per hr.

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Fig. 1 illustrates diagrammatically the second unit installation. The first unit was very similar to this except that all chemicals were proportioned by displacement proportioners and provision was made for heating and deaerating the available pure condensate separately.

The reagents selected were commercial 75 per cent phosphoric acid and caustic soda. These chemicals were fed by means of displacement proportioners in the first unit and by electrically operated proportioners in the second unit. Controls were mounted on a panel board for ease in adjusting the increase or decrease in the reagents as dictated by the water analysis. The phosphoric acid was proportioned to the flow of contaminated condensate and introduced beyond the vent condenser ahead of the deaerator, as indicated in Fig. 1. The application of phosphoric acid at this point broke down the carbonates, releasing free carbon dioxide which was eliminated from solution by the deaerator. After deaeration, caustic soda was added in proportion to the contaminated condensate, raising the pH value of the phosphate-treated deaerated water to approximately 9.5 to 9.7.

After sedimentation, the water was filtered through vertical anthracite filters and again treated with phosphoric acid before delivery to the boiler feed pump.

Filters were back-washed from the sedimentation tank and the back-wash water returned thereto, and provision was made in the piping for returning the rinse water to the sedimentation tank without any loss of heat. This was accomplished by locating the back-wash pump beyond the filters instead of ahead of the filters, as is considered customary.

Although previous experience indicated that the hardness would be reduced to less than 1 ppm in the effluent water from the filters, it was feared that some deposition of calcium phosphate would occur in the economizers because of the increased temperatures; for it is known that calcium phosphate becomes more insoluble with increasing temperatures. Therefore, it was considered desirable to reduce the pH value of the filter effluent to

8.0 to 8.5, so as to increase the solubility of calcium phosphate under the higher temperature conditions existing in the economizers, and to control the pH value in the boiler concentrate within certain limits.

With the initial installation of the first boiler, this was accomplished by feeding sulphuric acid at the point indicated in Fig. 1. The acid was fed by a double-displacement type chemical feed in which the flow of acid is continuous and at all times proportional to the filter effluent. This method of feeding acid was admirably suited to the condition, because of its simplicity and the fact it is a closed system, avoiding any recontamination of the deaerated feedwater with oxygen. A pH recorder was installed at a point beyond where the acid was introduced to control and record the results of the acid treatment.

Later, a 2-per cent phosphoric acid solution was substituted for sulphuric acid. This served the same purpose as the sulphuric acid in controlling the pH value of the feedwater and, at the same time, introduced phosphate into the boiler concentrate. This excess phosphate was recovered by recirculating a portion of the boiler concentrate from the 1400-psi drum to the sedimentation tank of the hot-process softener. The boiler was flashed at 10 psi in an intermediate flash tank and the steam utilized as part of that required for heating the water in the hot-process softener.

The recirculated boiler water provided the excess phosphate necessary for complete precipitation of the hardness in the sedimentation tank, and the only phosphoric acid added by the chemical feeds was that theoretically required for the precipitation of the calcium salts.

Test results were as follows:

Source of Sample	pH Value	Ppm Hard.	Ppm PO <sub>4</sub>	Ppm Cl as NaCl	Ppm Turb.	Calculated Total Solids
Softener inlet	7.8	5.0	0.0	8.2	0.75	...
Softener outlet	9.6	0.0	4.5	11.7	0.5	...
Finished water	8.5	0.0	7.0	11.7	0.0	...
Boiler water	10.0	...	65.0	135.0	0.5	272

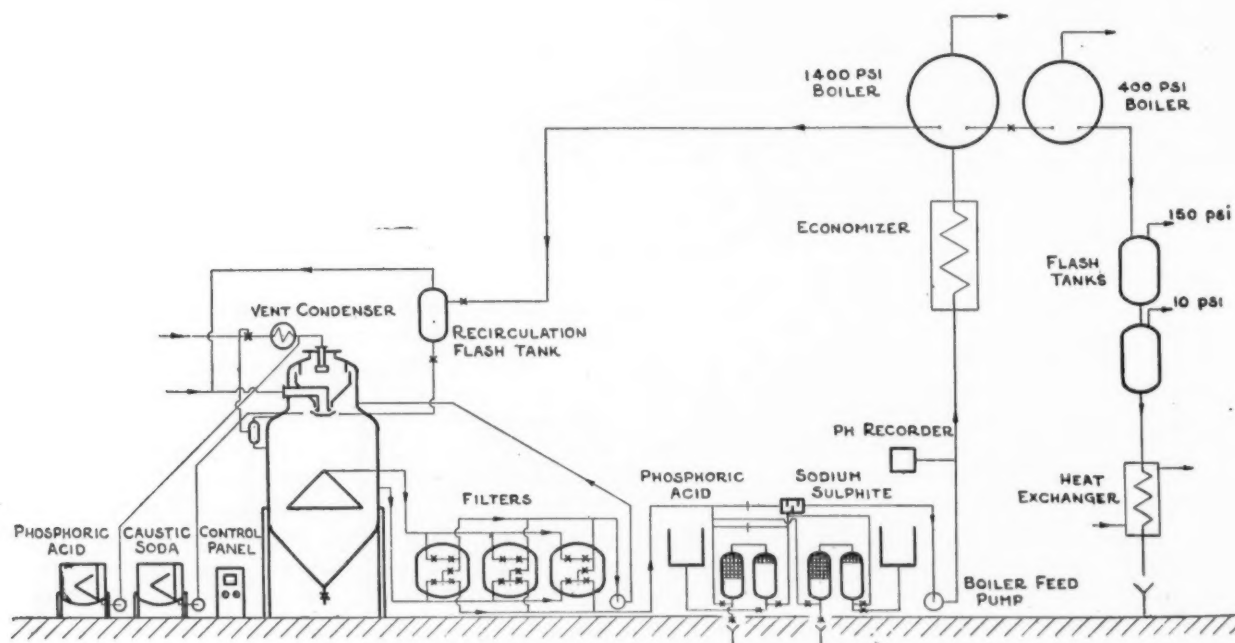


Fig. 1—Flow diagram of water-conditioning equipment

The phosphate concentration in the boiler water was maintained between 50 and 75 ppm  $\text{PO}_4$  and the excess in the sedimentation tank at approximately 5 ppm. The pH value of the softened water was controlled with caustic soda at values of 9.5 to 9.7 and that of the concentrated boiler water was approximately 10 to 10.5.

Another interesting feature of this system is that the 1400-psi boilers are blown down continuously directly to the drums of the 400-psi boilers. The latter are blown continuously to an independent flash system which discharges its flashed steam at 150 psi and at 10 psi to the low-pressure steam mains and the remaining unflashed blowoff water goes to waste through a heat-exchanger, the heat being exchanged to the cold feedwater. This method of operation has proved very satisfactory and becomes practical, because the 400-psi boilers are capable of operating at a much higher concentration of total solids than the 1400-psi boilers.

At all times the concentrated boiler water in the 1400-psi units has been practically crystal-clear, indicating a total absence of sludge. A sample of boiler concentrate after 10,849 hr of steaming is shown with a sample of condensate in Fig. 2. The internal condition of the

throughout the boiler and economizer indicated the very thorough manner in which this method of treatment removed the sludge-forming constituents of the contamination.

The quantity of chemicals required in treating this water supply is exceedingly low. The principal cost of operation is the labor required to maintain optimum conditions in each unit constantly throughout 24 hr of the day. The exactness and the diligence with which control is maintained are in a large measure responsible for the excellent results that have been obtained in this installation.

It is interesting that while boiler outages were mandatory each 90 days with internal treatment, this is no longer necessary. The first unit ran 13 months before cleaning. At the time of this writing the second unit has been operating for over 22 months with no indication of accumulating deposits.

The foregoing facts indicate that these water-conditioning systems save a sufficient amount of previously lost power production, by reason of less frequent cleaning intervals, to amortize the investment in approximately two years time.

The writers believe that these installations are the only ones of their type installed in this country or abroad, where practically 100 per cent of the feedwater is chemically treated by external means for boilers operating at 1400 psi.

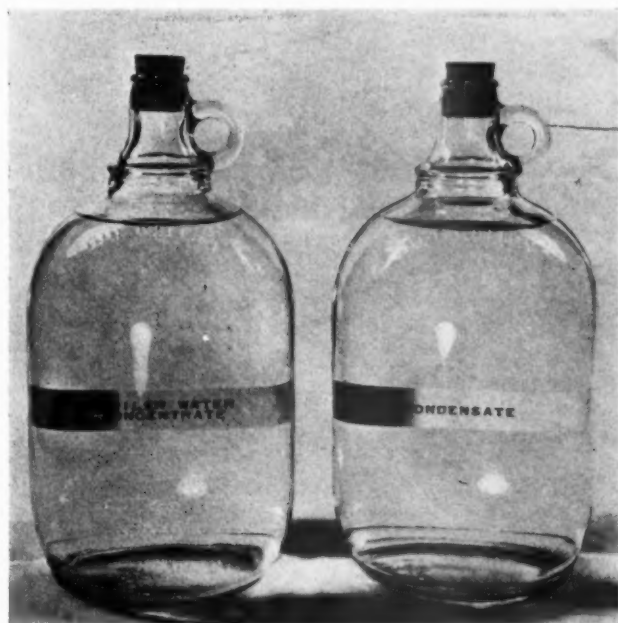
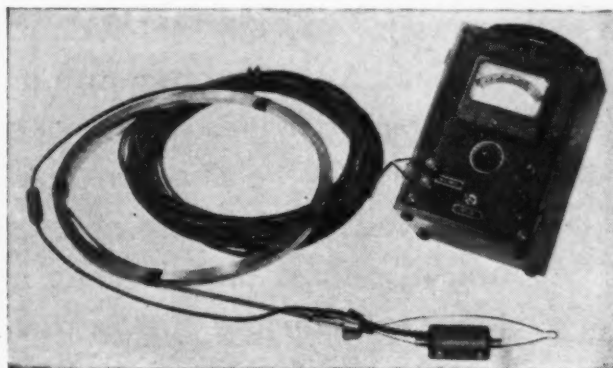


Fig. 2—Boiler concentrate after 10,849 hr of steaming compared with condensate sample. Labels are at back of bottles

boilers has verified the expectations based on the physical and chemical examination of the water at various points in the system.

The second unit was started up as a new boiler and, after nine months of operation, material turbed from various water-wall tubes weighed only 20 to 25 grams, a truly insignificant quantity. Furthermore, the composition of this material was practically all magnetic oxide of iron ( $\text{Fe}_3\text{O}_4$ ). In some samples a very small percentage of iron phosphate was noted. The economizer was remarkably free from corrosion and only a slight deposit of magnesium phosphate had accumulated in the last passes, not sufficient to be alarming or to necessitate cleaning. The complete absence of calcium phosphate

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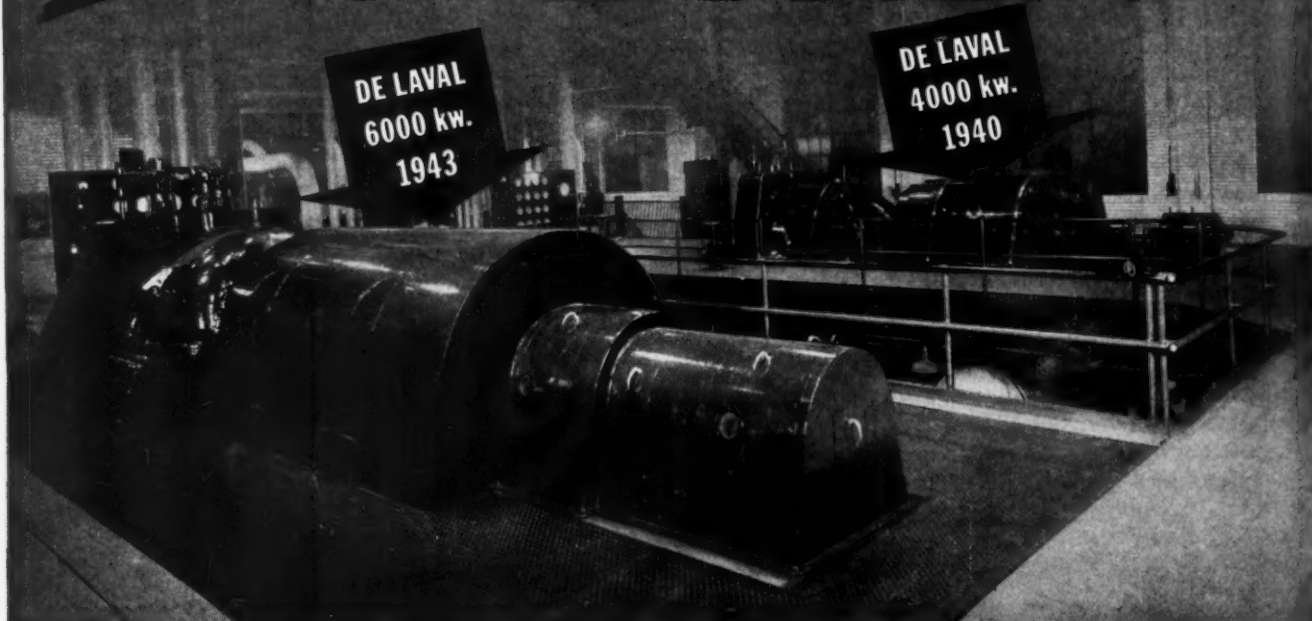
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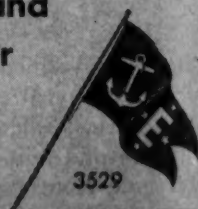
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# PROPULSION MACHINERY \*

By J. E. BURKHARDT

Technical Manager, Bethlehem Steel Co., Shipbuilding Division

A review of present practice in turbine and diesel-engine drive, with particular reference to employment of relatively high pressures and temperatures, and a discussion of the future possibilities of the gas turbine for marine propulsion.

IN THE last four years the compelling necessities of the war have made us all concentrate on production with little opportunity for new developments in design, and the practices that had become more or less standard by 1940 have been practically frozen. During the emergency all of the more important forms of propulsion have been applied extensively, partly to suit the needs of the various services but very largely also to make maximum use of available facilities, materials and manpower.

The striking case is, of course, the Liberty Ship with its venerable triple-expansion engine and accessories. Here was a plant that was a quarter century behind the current art as to economy. However, it was of proven reliability; it could be produced rapidly, in large numbers, by many shops; and it could be operated by people quickly trained. The choice was a "must" and the results have been gratifying.

A case that is almost equally striking, but less publicized, is the small diesel engine ranging from, say, 300 to 1300 hp per unit. For a long time it had been recognized that, in the field of the smaller powers, the diesel has dominating advantages over other forms of propulsion. There was a sudden and vast demand for such units for the new types of small craft in the armed services. Industry and government, in collaboration, standardized on a few sizes and designs and organized for large-scale production with provision for interchangeability and ready replacement. Units aggregating many millions of horsepower were readily produced and put into service and they undoubtedly determined the tempo of the war. This episode was little short of a miracle.

The activities in other forms of propulsion were less spectacular though perhaps more significant in their bearing on future marine practice.

Large diesels, both direct drive and geared, have been applied in the merchant program of the Maritime Commission. In this country the application of such engines to marine propulsion has lagged far behind Europe, mainly because owners were not convinced on such matters as reliability, maintenance and adaptability to American operating conditions. The performance of these new ships in the next few years should provide valuable lessons on these points.

Turbine-electric machinery has also been applied extensively in Escort vessels and tankers and in a group of large transport vessels. These turbine-electric drives made an indispensable addition to the sources of supply of propulsion machinery.

Aside from the groups mentioned and one group of high speed, four-cylinder, triple-steam engines on a special class of small naval vessels, practically all other important propulsion machinery, both naval and merchant, was of geared steam turbines. The U. S. Navy is using steam at 600 psi and 825 F for all combatant ships from destroyers up; for smaller naval vessels and merchant vessels the steam conditions are the now conventional 450 psi and 750 F.

## *Each Type of Propulsion Has Its Place*

What are the lessons of this wartime experience? The variety of the program has again demonstrated that there is no one type of propulsion to suit all cases; all have their place.

Diesel engines again demonstrated their superiority in the field of smaller powers but, as in the case of all displacement-type machinery, they require more maintenance. Where they have been used in large numbers and provision for repairs and spare parts could readily be made, they have given excellent service. In the case of the larger foreign-built engines where the normal supply of spares was not easily forthcoming and the high grade of personnel to make voyage repairs was not available, there have been serious interruptions in service.

In the application of the smaller diesel engine the war has provided considerable experience with the principle of multiple units driving through gears and flexible couplings. Maneuvering and reversing outside of the engine by means of clutches and gears and by feathering propellers have also been applied in many cases with apparent success. Although the principles here involved had been used extensively for small boats the actual experience gained with larger powers is notable and undoubtedly will be reflected in future practice on certain classes of floating equipment.

In the steam field the extensive wartime operation of modern naval vessels has proved that steam conditions of 600 psi and 850 F are thoroughly practical with the materials available. These comparatively simple alloys now have been used on a large scale and will be commercial after the war at little or no premium in price.

Those who have been skeptical of electric drives in the past now have the assurance that in the war they have proved to be practical and reliable even in the hands of people having no special experience in that class of equipment. War experience has emphasized the importance of reliability in the propelling machinery on which every vessel with her precious cargo depends to get through to her destination. It confirms the fact

\* A talk before the Research Panel, American Merchant Marine Conference, New York, October 18, 1944.

that novel features must be developed to the reliable stage on shore before being used on shipboard.

When we look closely at the list of gains over the general practice of a quarter century ago no single revolutionary advance is apparent. Practically everything of importance in today's propulsion plant was then available in some form. All that has happened is development and improvement due to the application of more knowledge and better engineering.

What changes will the future bring? Will they be revolutionary? We may assume that the pattern of the near future will be generally like that of the near past; that the prevailing practice of twenty-five years hence will embody things now available or in sight but improved and perhaps perfected.

#### *Fuel Economy an Important Factor*

During the years preceding the war there was a good deal of emphasis on fuel economy. Some of the more conservative operators thought there was too much. However that may be, it can safely be said that much of the engineering advance made in that period was inspired by it.

Will this urge continue? On the one hand, improved engineering reduced fuel consumption while other operating expenditures were rising so that the fuel costs became proportionately less and therefore of diminishing importance. On the other hand, the trend definitely is toward higher ship speeds and larger powers so that, if fuel prices do not fall much below the prewar level, it can be assumed that fuel economy will continue to be an important consideration.

The criterion will remain as heretofore, that the steps taken to reduce fuel consumption must not threaten reliability nor add unduly to maintenance.

#### *Status of the Diesel Engine*

The diesel engine has attained a high degree of development, a notable achievement when one considers the inherent difficulty of the earlier mechanical problems. It is still the prime mover with the lowest fuel consumption. For this and for other and more important reasons it will continue to dominate the lower power field for some time to come. The greatest scope for improvement in the diesel engine would seem to lie in reduction of wear and maintenance. Continuation of the policy of conservative rating would seem to be essential, after which one might look for improvement in lubrication and materials for the wearing parts.

It seems probable that war experience will give impetus to further use of smaller units driving through gears and flexible couplings and that the scope of the diesel engine in the direction of higher powers will be extended in this way rather than by the use of larger single units.

In the field of steam there is at the moment considerable interest in the possibilities of higher pressures and temperatures following the advances accepted in land work. In comparing marine and land installations it is important that the larger the unit the greater is its inherent capacity to utilize high steam conditions and the average marine unit is much smaller. However, there is a compensating effect in that marine turbines are not tied to fixed frequency as are turbine-generators and,

therefore, can be run at speeds more favorable to efficiency.

#### *Proven Steam Conditions*

For merchant ships 450 psi and 750 F are now standard. Extensive experience with 600 psi and 850 F has already been had in naval vessels and can be used for merchant vessels if owners are interested. Such pressure and temperature would reduce fuel consumption about 6 per cent. Still higher pressures up to 1200 or 1500 psi appear to be practical for ships of comparatively high powers, say 10,000 shp or more per shaft. At these pressures, however, something must be done to prevent the steam at the exhaust end of the turbine from becoming too moist or there will be erosion of the blading and inefficiency due to action of the water on the moving blades. Excessive moisture in the exhaust end is usually avoided either by increasing the initial superheat temperature or, if this is undesirable, by reheating the steam after it is expanded part way through the turbines.

Both of these schemes are used ashore, the first being the more common. They go up to 950 F, and are in a position to control this temperature within narrow limits and there are indications that this is necessary if metallurgical difficulties are to be avoided. This control is not so easy in a marine installation because the load varies widely and quickly during maneuvering. Hence, for the same degree of reliability a marine installation should be run about 75 deg lower than a land installation of generally similar design. These considerations indicate that the maximum suitable steam temperature for marine work is something under 900 F with the commercial materials available at present. Metallurgical research now under way may raise this limit in the not far distant future.

Reheating of the steam after leaving the high-pressure turbine and before entering the low-pressure cylinder can be done either by returning the steam to the boiler or by passing it through a reheater using boiler pressure steam as the heating agent. The former method was used on the *S.S. Examiner*, a Maritime Commission freighter with a 1200-lb installation. This vessel has now been running nearly three years and has given good service. Four large ore-carrying vessels are now under construction for still higher pressure, using the steam reheating method. The latter is simpler but less efficient by about 2 per cent because the reheat temperatures are necessarily lower.

For those interested in fuel economy, and with due regard for the necessity of a background of experience in order to insure no undue engineering risk, we should say that the highest we should go with present commercial materials is 1500 psi and 875 F. Applied to an installation of over 10,000 shp per shaft these steam conditions would give a fuel rate of just about half a pound per shaft horsepower per hour.

The water-tube boiler, now practically universal, has attained very satisfactory performance. The adoption of economizers and air heaters to reduce gas outlet temperatures, and other detail improvements, have increased the efficiency to a point where there is little room left for further gain.

The higher steam pressures led to the use of deaerating feed systems, to prevent boiler corrosion, and controlled feedwater treatment to retard priming and scale forma-

tion. These measures were so effective in improving reliability and reducing maintenance that they are now applied to low-pressure plants as well as high-pressure.

The improved designs and practices have resulted in a marked increase in output for a given weight and space and a simplification of the boiler plant through reduction in the number of units.

Much study has been given to the possibility of further reducing boiler weight and space through the application of forced circulation. However, since the ratings now used in merchant practice are only a fraction of those possible with the simple natural-circulation boiler, as demonstrated in Navy service, there appears to be no immediate reason for the application of forced circulation in merchant ships.

#### *Future of the Gas Turbine*

Research on gas turbines, active in this country and abroad over the last few years, may culminate in a successful prime mover competitive with other types. Recent aerodynamic and mechanical research has produced an efficient compressor, and metallurgical research is producing new alloys which maintain their strength at extremely high temperatures, both of which are essential to the success of the gas turbine. These elements are now being incorporated in complete power plants operating at 1200 to 1500 F.

The outstanding features of the gas turbine are its simplicity and independence of large amounts of cooling water. The first applications will probably be where these advantages are of major importance, as in aircraft and locomotives. The gas turbine will probably be lighter in weight and occupy less space than other prime movers—features that will be of particular importance on high-speed vessels of the destroyer type.

It is believed that in the immediate future the efficiency of the gas turbine will not materially exceed that of a high-pressure, high-temperature steam plant or equal that of a diesel engine unless a complicated cycle is adopted and this will detract somewhat from its inherent advantage of simplicity.

From the marine standpoint, the first problem is to produce an efficient gas turbine capable of continuous operation for periods long enough to establish reliability. This phase of development is underway and shows some promise of success, after which will come the task of adapting the unit to a marine installation to which it does not lend itself very well. The power versus rpm characteristic of a simple gas turbine is not as suitable for maneuvering as the other prime movers now used for ship propulsion and, therefore, a suitable transmission system must be developed to reconcile this characteristic with that of the propeller. The problem of adapting the gas turbine to marine service is not insurmountable, but it should be recognized that complications will be introduced that will partly offset the basic advantages.

#### *Effects of Propellers and Hull Design*

All the power generated by the propelling machinery is delivered to the propeller for conversion into thrust to propel the ship and the efficiency of this conversion is of the utmost importance. Up to about twenty years

ago approximately one-half of the power delivered to the propeller was lost in the slip stream. The best performance on single-screw ships today has reduced this loss to about one-fourth, due almost entirely to refinements in the design of the propeller and fairing of the hull, rudder and appendages aft. It is not generally realized that the effect of this improvement upon the economy of propulsion is of the same order of magnitude as that accomplished by superior engineering in the propeller machinery itself, and it has been done at very little increase in first cost and with no engineering risk or added maintenance. In the same period there was some improvement in twin screws, too, but not nearly to the same degree, and still less in the case of quadruple screws.

Of the thrust required to propel the average merchant ship approximately 75 per cent is absorbed by skin friction. The rest goes into wave and eddy-making and is lost entirely. The effect of the skin friction reappears in the wake, and because a propeller on the centerline is in a position to take the fullest advantage of this, a substantially higher propulsive efficiency is inherent in the single screw. It is more efficient than twin screws by perhaps 10 or 15 per cent, which, in turn, are better than quadruple screws by a similar amount.

A better utilization of wake in multiple screws would seem to provide the biggest single possibility of improvement if someone could think of a method of doing it without too radical a change in the hull form aft.

For many years it was believed that there was a rather definite limitation of power for a single-screw ship but we have recently gone up to 12,000 and 14,000 hp with no difficulty. However, multiple screws are inevitable for many ships and one should look for further improvement, for which there seems to be room, through self-propelled model tank experiments.

The total weight of machinery tends downward for all types. In steam plants the savings have been principally in the boiler plant. Early apprehensions that higher steam pressures would increase overall machinery weight have not materialized; the trend seems to be the other way, if anything.

The space allotted to the propelling machinery of merchant ships is usually settled by the archaic tonnage rules which require that if the machinery space is not less than 13 per cent of the total volume of the ship, a deduction of 32 per cent may be made in arriving at the net tonnage. The effect of this rule has fixed the volume of machinery space at 13 per cent whether or not it was required by the machinery. It is interesting to note that as we have doubled and sometimes trebled the power to meet the demand for faster ships, it has been accommodated in the same space with no difficulty whatsoever.

A movement has started toward a revision of the tonnage rules and this particular one will come under review. However, as the speed and power of merchant vessels increase, the artificial effect of the rule diminishes and may vanish by the time a change in the rules is effected.

In the welter of war activity there undoubtedly have been developed ideas not now generally known or appreciated as being applicable to the problems of marine propulsion. The release of these with the correlated experience will result in improvements impossible to appraise at this time.



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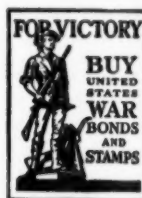
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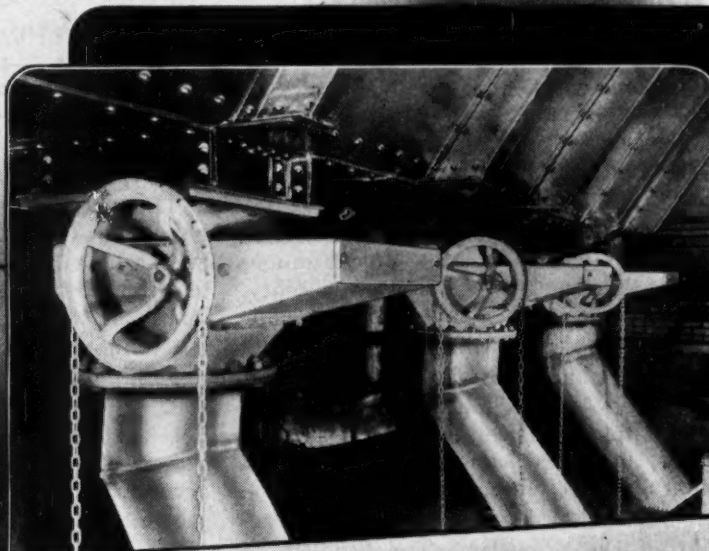
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# Thermocouples for Furnace-Tube Surface Temperature Measurements

By C. G. R. HUMPHREYS

Combustion Engineering Company, Inc.

This article describes a method of embedding and protecting thermocouples against being injured or dislodged by slag, the novel feature being a protecting plate with about  $\frac{1}{16}$  in. of the couple exposed at the junction. This arrangement has the advantage of not weakening the tube by drilling a hole or cutting a groove for the leads. Comparative readings with other methods of attachment are given.

THE thermocouple here described and illustrated in Fig. 1, has been used to measure tube temperatures on large high-pressure steam generators as well as small low-pressure units. It employs a steel cover-plate protection against slag and the effect of water lancing. While the life of this rugged couple is affected by its location, several months' usefulness is common and one application outlived its required life by more than a year. Accuracy is well proved by comparison with other methods, as the summarized examples indicate.

The small lip gouged by a round-nose chisel need be no larger than  $\frac{1}{32}$  in. deep by  $\frac{1}{8}$  in. wide, or smaller, if possible. It assists in the drilling of two slanting holes of suitable diameter and  $\frac{1}{10}$  in. long for attachment of the wires. The holes are close to the tube's external surface and it is not necessary to bend the wires acutely as they leave the junction to enwrap the tube. For furnace-wall thermocouples, No. 22 AWG chromel and alumel glass-insulated wires are preferred, encased together in a flexible glass sleeve. This duplex wire is available as a standard thermocouple wire. Before insertion into separate holes,  $\frac{1}{20}$  in. apart, the end of the duplex wire should be exposed for  $\frac{1}{10}$  in. and the individual wires filed clean and bright. After pressing them into the holes, the lip is lightly punched back to re-assume the original tube contour as indicated in the sketch.

Some engineers prefer that the two wires be peened as a single welded bead at the hot junction, but this necessitates a larger hole in the tube and results in an uncertain point of junction. If the insulation of the wires should become impaired at the bead, the actual junction may well be beyond the tube surface. Moreover, the separate imbedding of two wires in an isothermal area (an area where the temperature is constant) is quite correct in principle for, where each wire joins the tube,

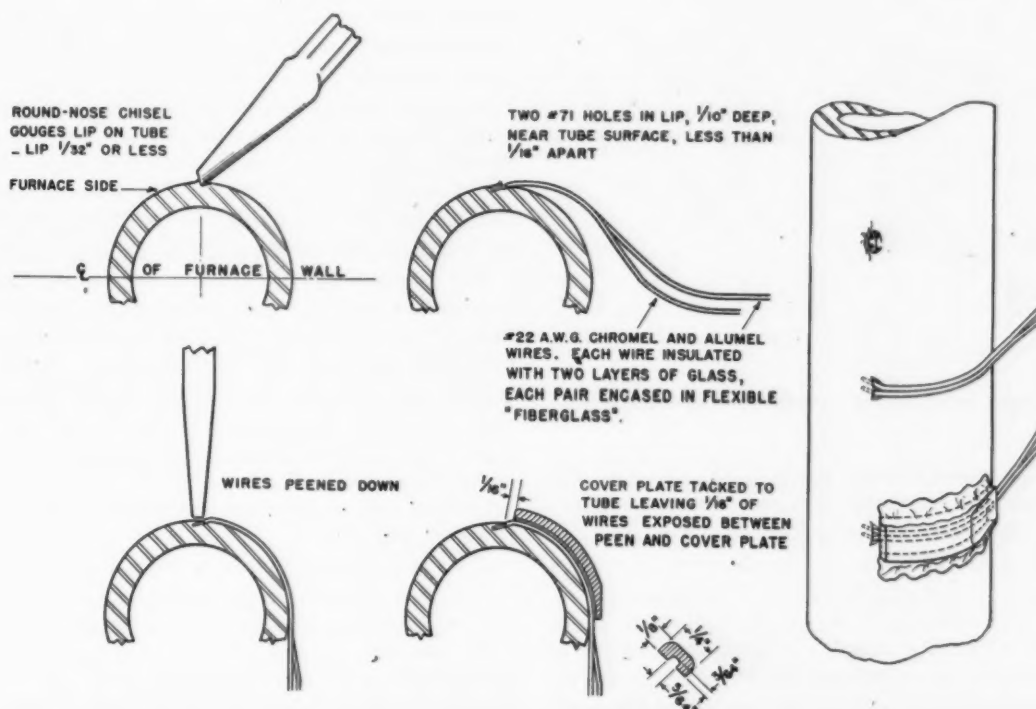


Fig. 1—Method of attaching junction and protecting leads by cover plate

there is a source of electromotive force, namely, chromel-steel and alumel-steel. The algebraic sum of the two electromotive forces is the same as the electromotive force from alumel to chromel at the temperature in question.

Over the thermocouple leads is welded a steel cover plate. This plate is cut from a ring turned to fit the tube and contains a groove which accommodates the wires. Care should be taken when placing the plate to

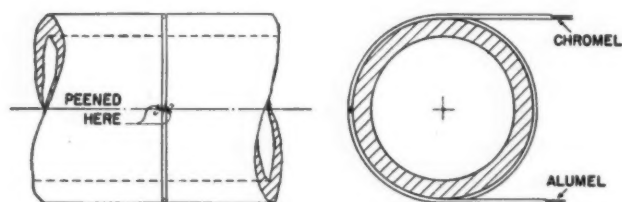


Fig. 2—Glass-insulated wires in  $\frac{1}{32} \times \frac{1}{32}$ -in. groove in tube with hole in each side

avoid crushing the insulation of the wires. The hot junction is not covered by the plate and the  $\frac{1}{16}$  in. of exposed wires is lightly coated by Alundum cement. This permits future examination of the junction. Before welding the cover plate, the tube must be free from all mill scale and ash. Speed in welding avoids overheating of the wires and plate. Also large weld scars should be avoided.

Basically, the employment of a cover plate on a thermocouple for such application would appear to be unsound, for it changes the surface of the tube. A furnace tube receives heat by both radiation and convection and neither should be modified. For heat transfer by

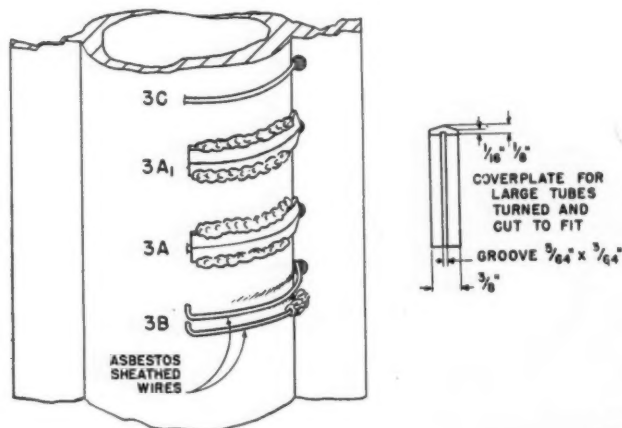


Fig. 3—Different methods of attaching thermocouples

radiation, the emissivity of the isothermal area must not be changed, and for convective transfer the exposed area and tube smoothness must not be altered. However, the examples here given indicate the smallness of the error involved by using cover plates on clean tubes, and in any case, the slag and ash conditions on the wall are continually changing. These examples summarize results of actual installations of thermocouples using the cover-plate method, with No. 22 duplex glass-covered chromel-alumel wires, as well as some other methods:

(a) With  $1\frac{1}{4}$ -in. O.D. water-wall tubes, cover-plated thermocouples were installed 1 in. away from couples of the type shown in Fig. 2. With clean furnace walls, couples in isothermal areas indicated a difference of 5 deg F; that is, the couples shown in Fig. 1 indicated 629 F, whereas those of Fig. 2 showed 624 F.

(b) With 3-in. O.D. finned water-wall tubes cover-plated couples were installed as shown in Fig. 3. The method described (3A) exposed  $\frac{1}{16}$  in. of wires between the hot junction and the end of the cover plate. Couples 3A and 3A<sub>1</sub> read alike within 1 or 2 deg F in 640 deg F total temperature, but it is preferable to expose the hot junction for future close examination.

(c) This represents a comparison of 3A and 3C, the latter being a standard thermocouple with cover plate omitted. This couple was held closely to the tube by a thin layer of Alundum cement. For a few hours 3A and 3C were equal but 3C soon read consistently higher than 3A by 23 deg F in one pair and 12 deg F in another until their complete failure occurred after 72 hr. It was pre-

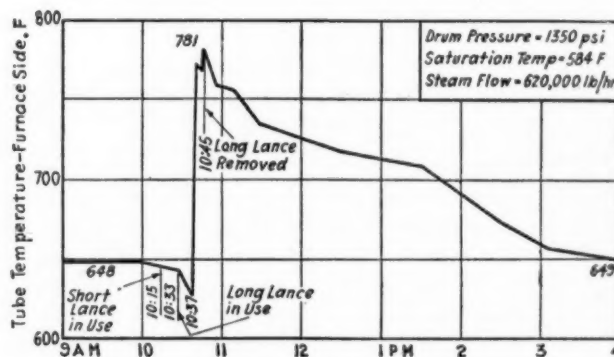


Fig. 4—Effect of lancing on tube temperature (Reproduced from A.S.M.E. paper on "Heat-Transmission Through Boiler Tubing," by Messrs. Davidson, Hardie, Humphreys, Markson, Mumford and Ravese, 1943)

sumed that the enwrapped leads lost contact with the tubes causing conduction of heat to the hot junctions from the leads.

(d) The couple indicated by 3B used No. 14 AWG chromel and alumel wires, loosely sheathed by asbestos sleeving, peened in radial holes and purposely held  $\frac{3}{8}$  in. or  $\frac{3}{16}$  in. from wall. The total temperatures indicated by 3B were 32 deg F and 23 deg F, respectively, higher than 3A which indicated 630 F to 690 F.

For interesting experiments comparing effects of heat conduction to or from thermocouple hot junctions, as affected by wires of various thicknesses, the writer recommends reference to the following: "Heat Transmission Through Boiler Tubes," by H. Kreisinger and J. F. Barkley, U. S. Bureau of Mines, T.P. 114 (1915), and "Measurement of Metal Temperatures on Heat Receiving Side of Heat Exchanging Apparatus," by A. Williams, an unpublished paper before the A.S.M.E., December 1932.

(e) Thermocouples were installed in a section of 4-in. O.D. tube. The couples were all of No. 22 AWG single or duplex glass-covered chromel and alumel wires. The tube was located on a brick furnace fired by gas. Water was circulated through the tube which was heated by convection, also by radiation from a hot steel plate set opposite and 3 in. from all couples. Couple 3C was

held to the tube by a twisted wire. The results of a typical low-temperature heating and cooling run are tabulated and indicate the errors due to conduction of heat, along the couple wires 3B, to and from the hot junction during heating and cooling, respectively. The following example shows the indicated surface temperatures, in degrees F, with the different arrangements of thermocouples indicated in Fig. 3:

3A	3A <sub>1</sub>	3B	3C
152	155	162	156
181	181	196	184
212	212	221	214
215	217	225	218

The gas was then shut, the water not circulating but agitated, and furnace cooling expedited, with the following readings taken:

3A	3A <sub>1</sub>	3B	3C
203	208	194	
194	192	185	
180	180	169	Couple damaged
168	166	159	
171	170	164	

(f) Fig. 4 clearly indicates the immediate response of a thermocouple when subjected to scouring by air and water lances. The temperature soared after slag was lanced from the furnace-wall tube and fell slowly as more slag collected. Such hard duty required protection afforded by a welded cover plate.

Thermocouples should be installed with considerable care. This does not imply any added laborious painstaking effort. A furnace-tube application presents its problems and if these are satisfactorily treated initially, much repetition of work may be avoided. The couples shown in Fig. 3 illustrate the need for careful attention to details. The couple leads leave the furnace through <sup>3</sup>/<sub>16</sub>-in. holes in the tube fin and proceed through the furnace-wall insulating blocks and boiler casing. Expansion of the boiler walls and setting are, to some extent, independent of each other so that lead wires must have ample room for expansion with sufficient loose lead wire. Holes in fins and casing will have burrs and sharp edges and care must be taken to protect the leads at these points. The fin holes must be protected also with some refractory cement. Such attention to details is always worthwhile.

Where many thermocouple readings are to be taken, and where a direct reading potentiometer is not available, up to 75 per cent of conversion time and considerable brain fag may be saved by the use of a conversion slide rule, Fig. 5. The scales illustrated, if pasted on a cheap rule, are accurate to within 1 deg F over a wide range of temperatures encountered in power boiler operation, and if other ranges are needed, for these or other couple metals, they can be similarly drafted. Millivolts are pasted on fixed A and D sides, deg F on the slide. Set the 300-F mark against the cold junction degrees F and convert millivolts directly to degrees F. The supplementary temperatures 850-1050, also the separate millivolt scale from 16.5-21.7 should be "picked out" in red and will thus add to the maximum temperature, especially at the low cold junction degrees F.

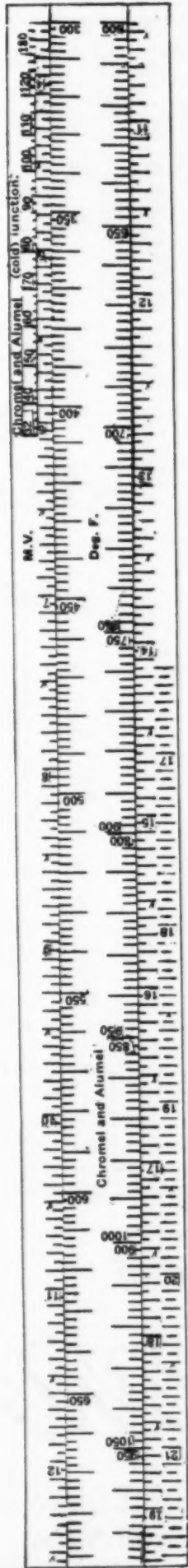
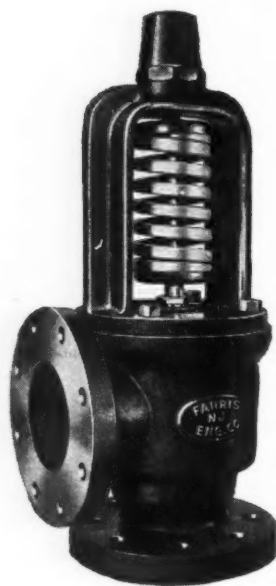


Fig. 5—Scales of convenient conversion slide rule

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### Early Petroleum History

The American Petroleum Institute has just issued a brochure marking the 85th anniversary of the petroleum industry which contains most fascinating historical information on that product.

It appears that the first oil well in the world was drilled on the banks of Oil Creek, near Titusville, Pa. by Colonel Edwin L. Drake who brought oil to the surface on August 27, 1859. However, petroleum had been known since early time. The Indians in New York and Pennsylvania had collected seepage oil long before the advent of the white man in North America and early settlers had used this seepage oil. In fact, George Washington listed in his will certain lands in Pennsylvania which contained a "burning spring."

In 1847 James Young began experimenting with the production of illuminating oil distilled from coal and oil shales, and in 1854 a chemist, Dr. Abraham Gesner, perfected an improved illuminant distilled from coal, which he called "kerosine," but which was known to the general public as "coal oil." Some of this "coal oil" was made from petroleum obtained from surface seepage, salt wells and oil shales, as well as from coal. In fact, about fifty small refineries, employing oil from these sources, were engaged in business when Drake drove the first well.

In the early days in Pennsylvania, Ohio West Virginia, Kentucky and Tennessee, many wells were driven for the primary purpose of getting underground salt and the presence of petroleum often ruined the brine, so that the wells had to be abandoned, as there was then no ready market for the oil.

The products of the refineries, following Drake's first well, in the 60's, 70's and 80's were kerosene and lubricants and the accompanying gasoline, then called "volatile spirits," was regarded as a nuisance, as its presence in the gasoline often caused lamps and lanterns to explode. It was not until the advent of the gasoline engine that its value was appreciated.

Other facts mentioned in the brochure are the first tank car built in 1865; the first oil pipe line completed in 1874 from the Pennsylvania oil fields to Pittsburgh; the first trans-oceanic oil shipment in barrels from Philadelphia to London in 1861; and the first oil tanker in 1869. Oil was discovered in California in 1866, in Wyoming in 1883 and in the Southwest around 1890. The cracking process was developed about 1910-11.

### Turbines for Russia

Thirty steam turbine-generator units to replace devastated power plants in the Soviet Union have been ordered from the Joshua Hendy Iron Works. Preliminary work is already under way on the sets, of which ten will deliver 2000 kw each and the remainder 500 kw each. It is understood they will form a part of the many package power plants now being built in the United States to supply electricity in ravaged areas recaptured by the Russians from the retreating Germans.

## Louisiana Engineering Society

The Annual Meeting of the Louisiana Engineering Society will be held in New Orleans at the St. Charles Hotel, January 11-13. The program will include technical papers on the supply of power and other services to war plants, dehumidifying of air with coils, aluminum as a structural material, the metallurgy of light metals, gas turbines, and aviation developments.

## Midwest Power Conference Scheduled for April

The eighth annual Midwest Power Conference has been definitely scheduled for April 9 and 10, 1945 at the Palmer House in Chicago. As in former years, it is being sponsored by Illinois Institute of Technology with nine other colleges and universities cooperating, in addition to local sections of several engineering societies. For the first time a whole session will be devoted to the gas turbine and other sessions will deal with industrial power plants, feedwater treatment, fuels and combustion, central-station practice, hydro and diesel power, and post-war planning. There will also be three electrical sessions. The Conference Director, Prof. Stanton E. Winston is now working on the program which he hopes to announce shortly in tentative form.

## Personals

E. R. Fish has retired as Chief Engineer of the Boiler Division, Hartford Steam Boiler Inspection & Insurance Company and is also withdrawing from the A.S.-M.E. Boiler Code Committee of which he has been a member since 1918 and its chairman for the past three years.

P. S. Dickey has been appointed Chief Engineer of the Bailey Meter Company, in charge of all engineering, research and design. He has been with that company continuously since his graduation from Purdue University in 1925 and previous to his present advancement was research engineer. H. H. Gorrie has been made Assistant Chief Engineer.

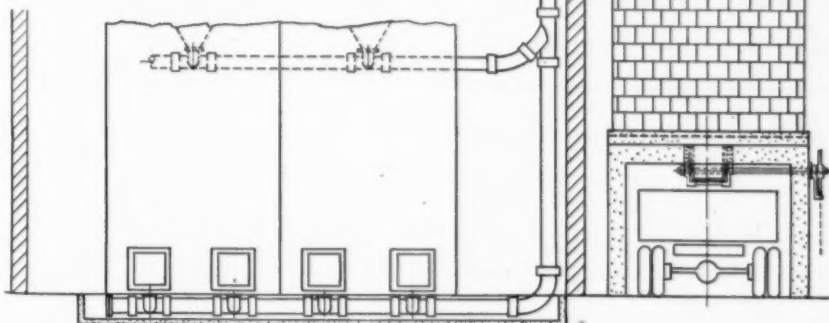
E. S. Lee, in charge of the General Electric Company's general engineering laboratory at Schenectady, has been re-elected Chairman of the Engineer's Council for Professional Development.

Kenneth McCreary was recently elected President of the Goetze Gasket & Packing Company. He has been with that company since 1932 and served consecutively as assistant to the president, treasurer and vice-president.

S. R. Edwards has been placed in charge of Yarnall-Waring Company's recently opened office in Dallas, Texas. A graduate of Purdue University, Mr. Edwards has spent the past fifteen years in engineering and sales work.

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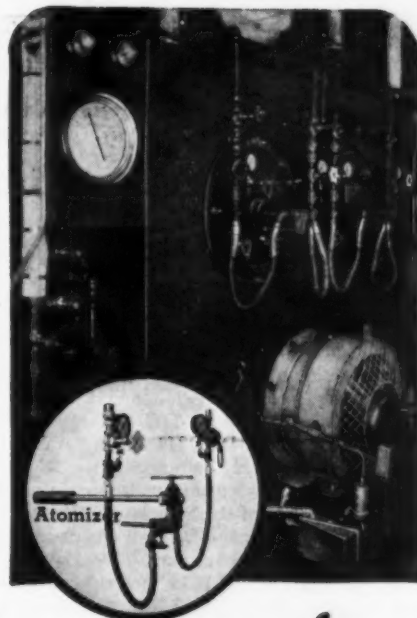


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# REVIEW OF NEW BOOKS

Any of the books reviewed on these pages may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

## A.S.T.M. Standards—1944 American Society for Testing Materials

The 1944 Book of A.S.T.M. Standards will be published January 1945 in three volumes: Part I—Metals (385 Standards, 2100 pages); Part II—Nonmetallic Materials—Constructional (450 Standards, 1700 pages); and Part III—Nonmetallic Materials—General (345 Standards, 2300 pages). This new edition will contain all of the standards of the Society in effect at the time of publication and all emergency specifications and provisions.

In each Part of this 1944 book the standard specifications, tests and definitions and the tentative standards are grouped—tentatives being compiled at the back portions of each part. The items for related materials or subjects are together in the respective sections on standards and tentative standards. Each Part is carefully cross referenced; each has two tables of contents—one by grouping of materials, the other in order of the serial designations. There is also a detailed subject index in each Part.

Cloth binding—\$10.00 for each Part; half-leather binding—\$11.00 for each Part.

## Methods of Advanced Calculus By Philip Franklin, Ph. D.

*Methods of Advanced Calculus* covers all the material which has become associated with a course in Advanced Calculus. Its difference from the usual treatise in the subject is to be found in the treatment. The applications of the mathematics are stressed rather than the rigorous proofs of the analyses.

Professor Franklin of Massachusetts Institute of Technology has written the text well, has inserted all the steps in the reasoning and has made constant references to previous well-numbered equations. The all too prevalent use of the expressions "it is evident—it can be easily shown—the student can verify" are absent in this work.

Each chapter has a list of references, and a complete bibliography appears at the end of the book. There are numerous problems at the end of each chapter, as well as a list of answers. The author has provided hints for the more difficult problems. Wherever possible, he has chosen problems from physics rather than from abstract mathematics.

It is to be regretted that the publishers did not provide more space between the formulas, especially in the problem sections where the type is smaller. In general, the text represents a departure from the usual in that the author has given consideration to the reader by saving the latter many weary hours of puzzling to provide details. *Methods of Advanced Calculus* will be a handy reference for the practicing physicist.

The book comprises 486 pages, size  $5\frac{1}{4} \times 8\frac{1}{4}$ , and includes 162 illustrations. Price \$4.50.

## Coals of Alberta—Their Occurrence, Analysis and Utilization

By Edgar Stansfield and W. Albert Lang

This Report (No. 35) issued by the Research Council of Alberta, is based mainly on tests and analyses made in its laboratories at the University of Alberta, Edmonton. Additional information is included from its Geological Division, from the Department of Lands and Mines of Alberta, and from publications of the Canadian Bureau of Mines. It is a comprehensive volume and covers substantially every aspect of the subject contained in the title. Half the book is devoted to Analytical and Technical Data by Coal Areas.

The book contains 174 pages, size  $6\frac{1}{2} \times 10$ , and is bound in paper covers. Price \$1.00.

# NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

## Fuel-Oil Atomizers and Ignition Systems

The Engineer Company has issued an attractive 32-page bulletin (OB-PC) covering its line of Enco fuel-oil atomizers and electric ignition systems for all types of pulverized coal burners. This bulletin is particularly pleasing in its typography and judicious use of color and illustrations. Enco baffles, burners, oil pumping sets and combustion-control regulators are also mentioned briefly.

## Ratio Control

The Askania Regulator Company has just published a 16-page bulletin (No. 101) on Ratio Control. It points out the manner in which Askania Ratio Control may be applied to many types of proportioning applications in the process industries. A novel feature of the bulletin is the orifice calculation chart. This offers engineers a quick and easy method of orifice size determination for air and gas flows.

## Deaerating Feed Tanks

The Marine Department of the Elliott Company has published a 30-page Deaerating Feed Tank Instruction Manual (NH-500). This pocket-size manual is designed to assist engine-room personnel in the operation and maintenance of the company's deaerating feed tank equipment and also to give a general idea of the extent of any repair job before undertaking it. The manual contains cutaway views, a colored insert showing a diagrammatic arrangement of a deaerating feed tank and a 2-page schematic diagram of a typical feed and condensate system.

## Gate Valves

A new Edward Gate Valve Catalog (No. 12-E1) has just been issued by The Edward Valve and Manufacturing Company which includes illustrations, dimensional data and complete details of design pertaining to its new line of cast steel gate valves. The new gate valves are built in 300, 600, 900 and 1500-lb classes and

in sizes of  $2\frac{1}{2}$  to 12 in., inclusive. All Edward gate valves 4 in. and larger are ball bearing equipped; in the smaller sizes bearing plates for yoke bushings are "Evalized," a special Edward plating process, to reduce operating effort.

## High Temperature Insulating Cement

Universal Zonolite Insulation Co. has just released an 8-page illustrated bulletin on Zonolite High Temperature Insulating Cement. The bulletin covers composition and characteristics, procedure for application, and technical data including a computation method for determining economical thickness of insulation and heat losses. Charts are given showing heat transfer through insulation and heat losses, and also outside temperatures for various thicknesses of Zonolite Cement at different hot face temperatures.

## Water Cooling Towers

C. H. Wheeler Mfg. Co. has issued an attractive 20-page catalog (No. 143) featuring its mechanical draft Water Cooling Towers. The principle of operation and details of tower and fan construction are admirably pictured in these pages together with numerous installation views. A table of relative humidities for varying dry and wet bulb temperatures is also given.

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## TURBINE BLEEDER LINE NON - RETURN VALVES

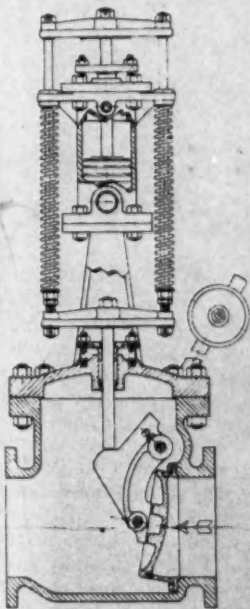
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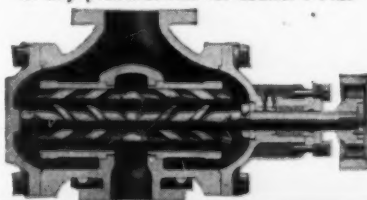
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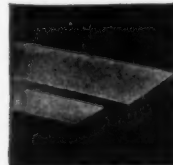
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### THE PHILIP CAREY MFG. COMPANY

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# NEW EQUIPMENT

## Cochrane C-B System

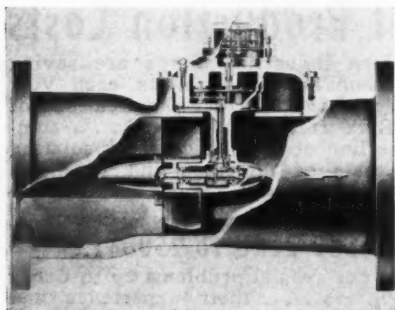
This unit is designed to solve the return of condensate from process equipment operating at pressures up to 200 lb directly back to the boiler without flash loss and with all of the sensible heat contained in the original steam. Fuel savings of from 10 to 15 per cent are claimed—boiler pressure more easily maintained—and boiler capacity increased.

Higher production rates are made possible by patented jet pumping principle involved. All condensate, noncondensable gases and entrained air are easily handled by the jet at high temperature with a constant differential maintained across the equipment creating positive drainage—with entrained air automatically discharged from the closed circuit before return to the boiler.

Because of the high back pressure maintained against the equipment, with constant flow of gases and liquids, there is no appreciable pressure drop in the steam chambers, as is the case when discharging to atmosphere or a low pressure. Hence, heat transfer rates are higher and more uniform, resulting in hotter heating surfaces—greater production at the same steam pressures—with less fuel costs.

## Improved Propeller Type Flowmeter

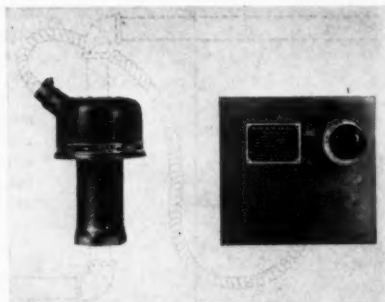
Builders-Providence, Inc., division of Builders Iron Foundry, has recently announced a new propeller type flowmeter



for main line metering with many improvements, including streamline venturi construction. This unit, called a Propelloflo Meter, has an 8-blade bakelite propeller molded in one piece. Rotation is transmitted through spur and bevel gears. Shafts rotating in ball bearings assure maximum power to drive indicating and recording devices or proportioning chemical feeders. A venturi throat evenly distributes the force of the flow against the full area of the propeller, resulting in improved accuracy throughout an exceptionally wide range of flow. Spiral flow is eliminated by straightening vanes just upstream of the propeller.

## Hancock Level Float Control

The Hancock Valve Division of Manning, Maxwell & Moore, Inc., announces the Hancock Electric Level Float Control. The manufacturer states that this control gives accurate and dependable liquid level to within a fraction of an inch.

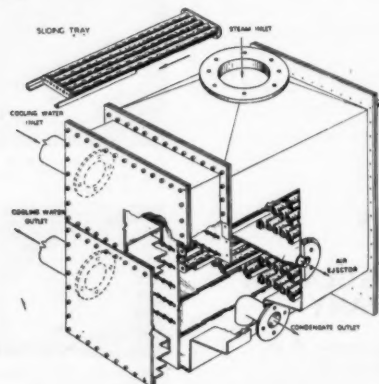


It has no electrical switching or contacts within or without the float chamber. There are no levers, linkages, bellows, stuffing boxes, cooling fins, mercury switches or wearing parts. By the simple adjusting of a screw the level of the liquid can be raised or lowered.

## New Condenser Designed to Increase Capacity

A new development in steam condenser design is being introduced by Contract Engineering of San Francisco. Known as the Dawes Condenser, the new unit offers a design which enables retubing and cleaning without necessitating long shutdowns.

The Dawes condenser is one-third the overall size of comparable conventional condensers, and is proportionately less heavy. Tubes are of special extruded surface construction. They are exchanged with ease and speed because of their arrangement in trays in a "file-cabinet" manner. In an installation utilizing a series of these condensers, manifolded, a single unit may be quickly cut in or cut out.



Present designs call for units up to 10,000 lb steam per hour at whatever vacuum is desired up to 29 in. Hg. These units may be manifolded in series to provide greater capacity as required.

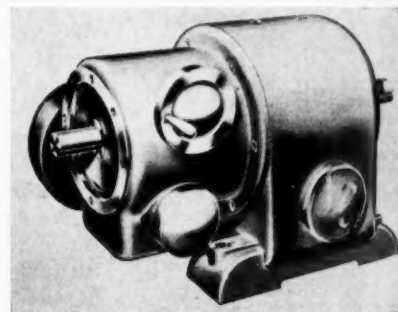
## Venturi-Type Safety Valve

Farris Engineering Co., manufacturers of precision valve specialties, announces the development of a line of Venturi-Type Safety Valves with special provisions for constant accurate blow-off, exceptionally great capacity, complete tightness of re-seating, minimum escape of vapor into the surrounding space and elimination of angular distortion and fouling.

One of the outstanding features of these valves is the patented "separator bell." This device causes the steam to make three changes in direction before passing into the atmosphere, and includes a drain for the condensed moisture into the body. Escape of vapor into the air is thereby minimized. The "separator bell" also helps to keep the spring cool by preventing steam from striking the spring, and improves freedom and maintenance of alignment by providing for higher support of the spring than in other designs.

## Variable Speed Drive

The Lombard Governor Corporation has perfected a compact new type of variable-speed drive for use in medium and higher horsepower geared drive power transmission.



Differing from conventional types of variable-speed units, the Lombard Variable Speed Drive uses the V-Belt as a control medium only; primary speed reduction being accomplished by conventional gearing methods. Through this new gearing arrangement 90 per cent of the power goes through conventional gears while only 10 per cent passes through the V-Belt. The lower gear ratio also affords finer hairline control, insuring peak production speeds. Low maintenance is made possible as the easily accessible V-Belt is the only part likely to need replacement over a long period of time.

## Water Analysis Apparatus

The Aero-Titrator, a product of Chief Chemical Corporation, furnishes a method for the determination of hardness, calcium and magnesium in waters, both industrial and potable. It makes use of a new endpoint, based on the foam-meter principle. Determinations are made within ten minutes and there is no waiting time to observe stability of lather. There are no moving parts to wear out and no delicate features to go out of adjustment.